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TECHNICAL MANPOWER IN NEW YORK STATE. VOLUME I.
BY- PEARCE, C.A. AND OTHERS
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GROUPS OF TECHNICAL OCCUPATIONS ARE COMPARED IN TERMS OF CHARACTERISTICS OF EMPLOYMENT, SOURCE OF WORKERS, AND EDUCATIONAL AND EXPERIENCE REQUIREMENTS. SURVEY FINDINGS ARE GIVEN FOR EMPLOYER TRAINING PROGRAMS AND EMPLOYER VIEWS AND POLICIES ON THE UTILIZATION OF TECHNICIANS. THE SURVEY DATA WERE DERIVED FROM A SAMPLE OF 17,414 ESTABLISHMENTS LOCATED IN NEW YORK STATE, WHICH ACCOUNTED FOR 50.4 PERCENT OF THE TOTAL EMPLOYMENT OF ALL BUSINESSES, EXCLUSIVE OF AGRICULTURE, DOMESTIC SERVICE, THE MILITARY SERVICE, AND SELF-EMPLOYED. BASED ON THE SAMPLE, IT WAS ESTIMATED THAT 148,684 WORKERS WERE EMPLOYED IN TECHNICAL OCCUPATIONS BY PRIVATE INDUSTRY AND GOVERNMENT AGENCIES IN NEW YORK STATE IN 1962. DATA FOR APPROXIMATELY 200 DIFFERENT TECHNICAL OCCUPATIONS ARE GIVEN. ABOUT 14,600 ESTABLISHMENTS REPORTED HAVING EMPLOYEES IN TECHNICAL OCCUPATIONS - 3.7 PERCENT OF A TOTAL OF APPROXIMATELY 393,500 BUSINESS AND GOVERNMENT ESTABLISHMENTS IN NEW YORK STATE. CONCLUSIONS WERE -- (1) ALTHOUGH THERE IS A LARGE NUMBER OF DIFFERENT TECHNICAL OCCUPATIONS, THEY DO NOT EMPLOY MANY WORKERS, DO NOT REPRESENT A LARGE DEMAND FOR MANPOWER OR A FIELD OF MANY EMPLOYMENT OPPORTUNITIES, (2) THESE TECHNICAL JOBS, NEVERTHELESS, ARE CRITICAL TO THE INDUSTRIAL ECONOMY, (3) AS THE PACE OF AUTOMATION TECHNOLOGY QUICKENS, SOME INCREASE IN TECHNICIAN-ENGINEERING RATIOS MAY BE EXPECTED, AND (4) BOTH HIGH SCHOOLS AND POST-HIGH SCHOOL INSTITUTIONS HAVE HAD A ROLE IN EDUCATING FOR TECHNICAL OCCUPATIONS. "TECHNICAL MANPOWER IN NEW YORK STATE," SUPPLEMENT A, SUPPLEMENT B, AND VOLUME II (VT 000 577 - 000 579) ARE RELATED DOCUMENTS. (PS)

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VOLUME I

STATE OF NEW YORK
DEPARTMENT OF LABOR

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TECHNICAL MANPOWER IN NEW YORK STATE

VOLUME I

STATE OF NEW YORK
NELSON A. ROCKEFELLER, *Governor*

DEPARTMENT OF LABOR
M. P. CATHERWOOD, *Industrial Commissioner*

In cooperation
with

THE STATE EDUCATION DEPARTMENT
JAMES E. ALLEN, JR., *Commissioner of Education*

STATE UNIVERSITY OF NEW YORK
SAMUEL B. GOULD, *President of the State University*

NEW YORK STATE DEPARTMENT OF LABOR
Division of Research and Statistics

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This report consists of volume 1 (the present volume), supplement A (appendix tables of volume 1), supplement B (job projections), and volume 2 (detail on each of fifteen groups of technical occupations).

Prepared by
C. A. PEARCE, *Director*
Division of Research and Statistics

and associates:

ABRAHAM J. BERMAN, *Principal Statistician*
HAROLD LOEB, *Associate Economist*
DOROTHEA MAIER, *Associate Economist*

with the assistance of:

CARL RAUSHENBUSH, *Associate Economic Research Editor*

Jean Fleischer, Elizabeth Kadish, Nicholas Neufeld,
Lawrence Palminteri, Sidney Rosenthal, *Senior Economists*
William Grainger, Sheldon Dorfman, Rita Israel, *Statisticians*
William Kasper, Bernard Kaye, Donald Thompson, *Economists*
and
Herbert Slotnick, *Head Statistics Clerk*

The Division gratefully acknowledges the assistance of those persons outside the Department, mentioned in the Preface that follows, who participated in the preparation of the report.

PREFACE

Advances in automation and related technology during the past decade or so have given new impetus to discussions concerning the adequacy and scope of technical education at the secondary school and higher educational levels. Some have interpreted these trends in technology as meaning that vastly higher proportions of the labor force must receive training in engineering, science, and technology and that if technical manpower needs are to be met there must be a particularly large expansion in technical manpower at the subprofessional level.

This subprofessional stratum of technical manpower is the primary focus of the present study. A broad review by the New York State Department of Labor five years ago of what manpower needs would be in the 1960's concluded that technological change would substantially increase those needs that are intermediate between craft skills and engineering and science skills.[1] But it also disclosed the fact that existing information about these intermediate occupations was spotty and highly unsatisfactory—more so than any other of the broad occupational groups.

In deciding to undertake a survey in this field the Department of Labor was also impressed by the fact that although technical education in the modern sense has been carried on for some forty years there has been no comprehensive survey of employment in technical occupations. The move to fill these gaps of information was in line with Section 531 of New York State's Labor Law, which requires the Industrial Commissioner to undertake investigations and supply data on the occupational needs of industry and on the effects of technological change and related matter.

The survey was planned and developed with the cooperation of the Division of Industrial Education of the New York State Education Department and the Office of the Dean for Two Year Colleges of the State University of New York. These agencies also made available substantial funds to employ field and consultative staff. The Labor Department is especially indebted to Assistant Commissioner Joseph R. Strobel, Division Director Dr. C. Thomas Olivo, and Bureau Chief Dr. Nelson J. Murbach of the State Education Department, and to Dean Paul B. Orvis and Associate Dean Kenneth Doran of the State University.

The survey was carried out under the direction of Charles A. Pearce, Director of the Labor Department's Division of Research and Statistics. Abraham J. Berman, assisted by Harold Loeb, Dorothea Maier, and Nicholas Neufeld, carried out the major part of the supervisory work.

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[1] See the New York State Department of Labor's 1960 publication *Jobs 1960-1970: The Changing Pattern.*

This report is presented in two volumes:

Volume 1 compares the various groups of technical occupations in terms of characteristics of employment, sources of workers, and educational and experience requirements; it gives the survey findings on employer training programs and employer views and experience on the utilization of technicians. There are two supplements to Volume 1. Supplement A contains the basic statistical tables that are referred to in Volume 1. Supplement B contains projections of technical occupation jobs in future years.

Volume 2 details the job content, technical-skill and subject-knowledge needs, and other characteristics of each kind of technical occupation.

In preparing Volume 2 of the report, the Division of Research and Statistics received valuable assistance from members of the faculties of several community colleges and high schools who served as consultants on the survey. They prepared a substantial part of the text of the major chapters of Volume 2. Their names, and the chapters of Volume 2 on which they worked, follow:

Angelo Amatulli, Chairman, Structural Department, Brooklyn Technical High School (Chapters I, II, VIII)

Sidney H. Avner, Associate Professor, New York City Community College (Chapters III, V, VII, IX)

Stanley M. Brodsky, Head, Division of Technology, New York City Community College (Chapters I, II, VIII)

William O. Olsen, Chairman, Related Technical Subjects, Bronx Vocational High School (Chapter III)

James J. Quinn, Chairman, Related Technical Subjects, Electrical Department, Brooklyn Technical High School (Chapter III)

Robin E. Spock, Assistant Professor, Staten Island Community College (Chapter III)

Frank Stewart, Acting Principal, Brooklyn Technical High School (Chapters I, II, III, IV, V)

These seven consultants also reviewed the manuscript of the report and contributed revisions. The Department especially appreciates the careful review given the manuscript by Messrs. Stewart, Avner, Brodsky, and Spock, and also by Herman W. Pollack, Associate Professor, Orange County Community College, and Alfred E. Davies, State Education Department.

These consultants were among some 40 members of faculties of community colleges, technical institutes, and technical and other high schools throughout the State who carried out a large task of field interviewing during the summer of 1962. Monies were made available from Title VIII of the National Defense Education Act partially to pay for these personnel and other services.

In addition to those mentioned above the following persons served on the field consultant staff:

New York City Area (incl. Nassau-Suffolk and Rockland-Westchester): George Bischof, Herbert Davis, Edward J. Egle, Jr., Louis H. Feldman, Morris H. Friedman, Reuben Fuchs, Richard N. Gaudino, Noel Greenridge, Arthur J. Hackett, Clement A. Herman, Jr., J. Edward Krauss, Robert Kirk, I. N. Lipton, Roman M. McNamara, Angelo Paradiso, William Pfister, Joshua Sterling, Adolph Suchy, Arthur Tetzlaff, Herbert J. Zipper.

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The Department is grateful to the many employers and members of their personnel and engineering staff whose cooperation and efforts made the survey possible.

M. P. Catherwood

M. P. Catherwood
Industrial Commissioner

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SUMMARY AND CONCLUSIONS

This survey was undertaken to learn about a group of occupations concerning which relatively little has been known. Technical occupations turned out to be a field of great diversity and complexity, which helps to explain why comprehensive studies covering it have not been readily undertaken.

In a sense the survey backed into a solution of the problem of defining the technical occupation field. The central focus of the survey was the technician and the technical specialist, persons who require some knowledge of science, engineering, or technology to perform their job. The professional engineer and scientist were to be excluded, as also were the traditional skilled crafts, and semiskilled occupations that do not require significant technical-education background or training time.

Most of the occupations that remained after these exclusions clearly belonged in the survey. Inevitably, however, there were a number of borderline jobs. Some of these were included, some excluded. For example, all technical writers and data-processing programmers and systems analysts were included. Radio and TV repairmen and registered nurses, on the other hand, were left out. (See chapter I.)

Generally speaking, technical occupations, as defined for the purpose of this survey, are semiprofessional in respect to the kind and amount of education and experience which they require. But there are a number of technical jobs for which a small minority of employers have professional requirements and also a number of jobs for which requirements in some instances are essentially along traditional apprenticeship-training lines.

The view that technical occupations are intermediate in skill between the crafts and engineers and scientists is generally apt, but there are exceptions. Some technical occupations have no affinity to any craft; manipulative and artisan skills play no real part, for example, in the work of a programmer, a mathematics aid, a technical writer, or most science aids.

Technical occupations do not necessarily involve long training periods. Training in the case of product testers, for example, may run considerably less than is needed in the typical skilled craft. At the other extreme, some employers require four years of college for high-level technicians.

Number of Persons and Kinds of Jobs

In all, 148,684 workers were found employed in technical occupations by private industry and government agencies in New York State in 1962. This number is believed to be complete except for technicians employed by farmers and self-employed technicians (who together probably do not amount to more than one or two percent of the total of all technical-level workers).

The survey revealed a multiplicity of technical occupations, many of them sparsely populated. The report defines almost 200 different technical occupations, and some tabulations in this report show additional occupational breakdowns.

These occupations have been grouped into the following fifteen broad classes (see also table A):

Draftsmen.—This is the third largest of the fifteen groups of technical occupations. Mechanical draftsmen are the largest of the draftsmen groups, but there are nearly as many architectural and structural draftsmen. Other types include electrical, electro-mechanical, highway, street, map, topographical, and plant layout.

Structural design technicians and related specialists.—This is a small group of technicians and specialists who assist architects and engineers in designing buildings and other structures.

Electro and mechanical engineering technicians.—This is the largest of the technical occupation groups, with 28 percent of the total in 1962. These technicians assist engineers in designing and developing new machines, equipment, systems, components, and products, and in carrying out complex tasks of installation, troubleshooting, and maintenance.

In the report they are classified by (1) *field* of engineering knowledge used (mechanical, electrical, electronic, and combinations of these); (2) kind of *product or equipment worked on* (e.g., electronic and mechanical testing, control, and measuring instruments; electrical machinery and equipment; aircraft and missile parts and equipment, etc.); (3) *function* performed (design, development, installation, troubleshooting and related functions, and combinations of these).

Mathematics technicians.—This small group of technicians assists engineers and scientists by making mathematical computations and calculations. A large proportion is employed in the aerospace industry.

Physical science technicians.—Well over half the 8,969 physical science technicians do chemical testing and analysis. About 1,000 work in the field of metallurgy, and about 800 are in the fields of physics, radiation, and nuclear energy. Smaller numbers are in meteorology, minerals and soils, and miscellaneous fields.

Biological, medical, dental, and related science technicians.—These form the second largest group of technical occupations. The largest subgroup consists of technicians and technologists engaged in medical laboratory testing and analysis. Specialists on operating X-ray machines and related equipment are the next largest group. Dental laboratory technicians, dental hygienists, dental assistants, therapists, and medical record librarians are among the other groups. (Nurses were not considered to be technicians for the purposes of the survey and so are excluded.)

Industrial engineering technicians and related specialists.—Grouped here, in addition to industrial engineering technicians (time and motion study and standards men, methods men, etc.), are specialists in planning, coordinating, expediting, estimating, equipment procurement and replacement, etc., and technicians concerned with quality-control methods.

Civil engineering and construction technicians and specialists.—This, the fourth largest group of technical occupations, consists of civil engineering assistants and construction technicians, such as construction superintendents, surveyors and instrumentmen, construction inspectors, and construction estimators and specification writers.

Sales and service technicians.—These persons promote and service technically complex products and serve as a source of information concerning the technical needs of customers.

Technical writing and illustration specialists.—These persons are engaged in preparing manuals and handbooks, promotional and sales brochures and displays, reports on technical developments for books and periodicals, and illustrations for various purposes.

Safety and sanitation inspectors and related specialists.—Over three-quarters are government fire, safety, and health inspectors. Most of the others are involved in industrial plant and insurance carrier safety activities.

Product testing and inspection specialists.—About 85 percent of these 8,100 specialists are employed by manufacturing establishments to test products for defects. Their jobs vary a great deal in difficulty; some border on semiskilled work.

Data-processing systems analysis and programming specialists.—Utilization of digital and analog electronic and electromechanical computers in connection with accounting and other business operations and engineering and scientific calculations is the common denominator in this group of technical specialists. All were included in the survey, even though some firms consider many in their employ to be professional workers.

Airway tower specialists and flight dispatchers.—Nearly all airway tower specialists are employed by the Federal Aviation Agency. Air transport companies employ flight dispatchers to coordinate flight schedules.

Broadcasting, motion picture, and recording studio specialists.—A majority are audio, video, acoustics, recording, and other studio technicians. Most of the remainder are equipment and maintenance technicians.

(For detail on the functions performed by the various kinds of technicians and technical specialists the reader should refer to volume 2 of this report, which contains a chapter on each occupation group.)

Table A. Distribution of Persons in Technical Occupations by Occupation Group

Technical occupation group	Number	Percent
All technical occupations	148,684	100.0
Draftsmen	20,972	14.1
Structural design technicians and related specialists	2,516	1.7
Electro and mechanical engineering technicians	42,031	28.3
Mathematics technicians	831	0.6
Physical science technicians	8,969	6.0
Biological, medical, dental, and related science technicians	25,445	17.1
Industrial engineering technicians and related specialists	6,901	4.7
Civil engineering and construction technicians and specialists	13,464	9.1
Sales and service technicians	1,932	1.3
Technical writing and illustration specialists	3,034	2.0
Safety and sanitation inspectors and related specialists	4,084	2.7
Product testing and inspection specialists	8,059	5.4
Data-processing systems analysis and programming specialists	6,153	4.1
Airway tower specialists and flight dispatchers	1,373	0.9
Broadcasting, motion picture, and recording studio specialists	2,920	2.0

Technicians and Technical Specialists

It is useful to distinguish between engineering and science *technicians* on the one hand and technical *specialists* on the other hand.

Technicians are defined to be persons of less than full professional rank who assist or support engineers or scientists by performing one or more engineering or scientific functions.

Technical specialists perform few or no engineering or scientific functions. Where they do, their application of technical or scientific knowledge is likely to be narrow in scope and repetitive; often—though not always—it is one that can be learned without protracted education or training.

A rough classification of persons employed in technical occupations in New York State in 1962 indicates that two-thirds were in the technician category and one-third (33.9 percent) in the specialist category:

	Number	*Percent*
Primary engineering technicians	30,426	20.5
Secondary engineering technicians	46,735	31.4
Science technicians	21,090	14.2
All technicians	98,251	66.1
All technical specialists	50,433	33.9
All technical occupations	148,684	100.0

Technicians were classified as primary engineering technicians if they assisted the engineer in one of his primary or principal functions (e.g., design or development). They were classified as secondary engineering technicians if they did work that engineers perform relatively infrequently (e.g., drafting, installation, and troubleshooting of products and production equipment).

(Just how the various technical occupations were classified in this grouping of technicians and technical specialists is indicated on pages 33-34 of volume 1. Also set forth at that point are examples of the overlapping in functions that occur among the technician and technical specialist occupations.)

Employment in Advanced Technology

A comparatively small proportion of all technicians and technical specialists in New York State are engaged in designing, developing, or troubleshooting control-devices and apparatus used in automated equipment and related kinds of testing and measuring instruments. Estimates cannot be precise, but roughly it is figured that around 15,000 persons are so engaged, 10 percent of the total number of technicians and technical specialists.

Nearly two-thirds of these are engaged in troubleshooting and related functions, one-third in design and development.

The aerospace industry (aircraft and missile production) is not a large industry in New York State and has dwindled—temporarily at least—since the survey was made in 1962. At that time the industry proper employed around 7,000 technicians and technical specialists, or 5 percent of all such workers in the State.

Grade Structure and Supervision

Although it was not possible in the present survey to match levels of skill and responsibility for the various technical occupations covered, there was recorded for each job whether it involved supervision over other technical workers of the same kind or, if not, whether it was a single-grade job or one of several grades.

About 5 percent of the 148,684 persons in technical occupations are employed in jobs that have significant supervisory responsibility. Of the remainder, somewhat more than half are nonsupervisory workers employed where there is only a single grade.

All grades	100.0%
Supervisory grades	4.9
Nonsupervisory grades	95.1
Single grade only	51.0
Multi-grade	39.7
Lowest grades	16.3
Middle grades	8.0
Highest grades	15.4
Grading system not reported	4.4

Large establishments are much more likely to have multi-grade structures for technical occupations than are small ones.

Probably the majority of persons in technical occupations are directly or indirectly supervised by professional engineers and scientists. Employers' reports indicate that 42 percent are supervised directly by engineers and scientists (including mathematicians and architects), while 34 percent are supervised by technicians or technical specialists of higher grades. The remaining 24 percent are supervised by persons in other occupations, mainly plant, department, or production managers or supervisors. (See chapter II, pages 27-28.)

Employment of Women

Relatively small numbers of women are found in technical occupations: 18,335 were employed, and they were only one-eighth of all employees in technical occupations—a far smaller proportion than the one-third among all nonagricultural workers in New York State in 1962.

The proportion of women is especially low in the occupations of draftsmen and electro and mechanical engineering, industrial engineering, and civil and construction engineering technicians. On the other hand, relatively large proportions of the mathematics technicians and of biological, medical, dental, and related technicians and specialists are women.

As a field of employment for women, the biological-medical-dental occupations overshadow all others. Eighty percent of all women employed in technical occupations were in this group in 1962.

About 70 percent of all persons in technical occupations work in establishments having no women in such jobs, and half of these work for employers who stated that they would not hire, or would be reluctant to hire, women in the occupations in question. (See pages 31-32.)

Unionization

While around 30 percent of all nonagricultural employees in New York State are covered by a union agreement, only about 17 percent of workers in technical occupations are in this category.

Broadcasting and related studio specialists, with 77 percent covered, were most fully unionized; they were followed by product testing and inspection specialists with 42 percent, and electro and mechanical engineering technicians with 33 percent (those unionized in the last group being primarily troubleshooters and related technicians).

On an industry basis, by far the highest proportion of union coverage of technical occupations was in the transportation, communication, and public utility group, especially in the communication industries and in air and railroad transportation. (Pages 32-33.)

Basis of Pay

About 78 percent of the workers in technical occupations are salaried, the remainder being paid on an hourly basis. Of all the groups, product testers and inspectors were found most often employed on an hourly basis.

The survey questionnaire also asked how many technical occupation workers were paid less than $2.00 an hour or $75 a week. Of the 3.7 percent who were, about three-quarters were in the medical technician group and the product testing and inspection group. (Page 22.)

Industry Picture

Taking all persons in technical occupations together, manufacturing industries employ by far the largest number—about 40 percent of the total. Government is the second largest employer, with 14 percent of the total; private medical services are third.

Industry division	*Number*	*Percent*
All industries	148,684	100.0
Manufacturing	59,085	39.7
Government	21,063	14.2
Private medical services	16,496	11.1
Research laboratories, architectural and engineering services	14,749	9.9
Transportation, communication, and public utilities	14,084	9.5
Construction	7,523	5.1
Private colleges and schools	3,754	2.5
All other	11,930	8.0

Types of technical occupation employment vary greatly from one industry to another. For example, the construction industry employs about 6,000 civil engineering and construction technicians and specialists but few others in technical occupations. Similarly, hospitals and other medical services employ mainly biological, medical, dental, and related technicians.

Government employs over 90 percent of the airway tower specialists, almost 80 percent of the safety and sanitation and related specialists, a third of the civil engineering and construction technicians and specialists, and a fifth of the biological and medical technicians. Manufacturing is the largest employer of draftsmen, electro and mechanical engineering technicians, mathematics technicians, industrial engineering technicians, physical science technicians, and product testing and inspection specialists. (Pages 22-24.)

Area Picture

New York City employed 42 percent of all persons in technical occupations in 1962, far more than any other area. Relative to total area employment, however, technical occupation employment was lowest in New York City; it was highest in the Binghamton and Nassau-Suffolk areas:

Area	*Number*	*Percent distribution*	*Percent of nonfarm employment*
New York State	148,684	100.0	2.4
New York City	62,739	42.2	1.8
Nassau-Suffolk	22,835	15.4	4.5
Buffalo	12,968	8.7	3.0
Rochester	8,163	5.5	3.5
Albany	7,241	4.9	3.1
Westchester	5,749	3.9	2.5
Syracuse	5,490	3.7	2.9
Binghamton	3,886	2.6	4.9
Utica	2,890	1.9	2.8
All other	16,723	11.2	2.3

The importance of a particular kind of technical employment depends in large measure on the kind of industry located in an area. The Nassau-Suffolk area, for example, has a relatively heavy proportion of electro and mechanical engineering technicians, but is relatively light in most other categories. (Pages 24-26.)

(Note that the present survey was set up so as to supply data on an area basis. See tables 6, 8, 10, 11, 12, 22, 26, and 47 in supplement A to volume 1.)

Size of Establishment

Relatively few small establishments employ technicians or technical specialists. The majority of workers in these occupations are employed in establishments with 500 or more workers.

Size of establishment	*Workers in technical occupations*		*Establishments with technical occupations as a percent of all establishments*
	Number	*Percent distribution*	
All sizes	148,684	100.0	3.7
1– 3	5,798	3.9	1.9
4– 19	10,078	6.8	2.9
20– 49	9,706	6.5	8.9
50– 99	11,937	8.0	18.0
100– 199	11,447	7.7	29.9
200– 499	15,430	10.4	44.3
500– 999	15,936	10.7	69.4
1,000–1,999	16,096	10.8	76.8
2,000–4,999	18,801	12.6	84.0
5,000 or more	33,455	22.6	94.5

The relatively small technical occupation employment in small establishments reflects the heavy concentration of these establishments in trade and service industries and the fact that where technical needs do exist they can often be met by a single engineer, a working proprietor, or by utilizing the services of engineering firms temporarily as needed.

Research and Development

Research and development activities utilize many workers in technical, engineering, and science occupations. Establishments engaged in these activities were 19 percent of all establishments that had technical, engineering, or science employment in 1962 but employed 54 percent of all such workers in that year.

The bulk of technical, engineering, and science employment in establishments carrying on research and development activities was in manufacturing. Government was second in this respect. (Page 17, table 5 in supplement A to volume 1.)

Education and Experience Requirements

Nearly all employers require high-school graduation as a condition of employment in technical occupations. Nearly half require more.

Employers were asked to report, for each of their technical occupations, the required qualifications in respect to formal education and work experience that were in effect at the time of the survey. The required qualifications were the minimum ones needed by new entrants into the job, at a given grade, whether they were obtained by recruitment or upgrading. *Required education* was considered to be the least amount of education acceptable by the employer for the job in question. *Experience* was the amount of job experience, if any, required as a supplement to the minimum required level of education.

In addition to what they required, employers also were asked to state what educational qualifications, if any, they would *prefer* to set for technical occupations. (See pages 44-45.)

Education

Employers of 47 percent of all persons in technical occupations require some post-high-school education as a condition of employment in these occupations. Employers of the remaining 53 percent have educational requirements that do not go beyond completion of high school.

Of the technical workers covered by requirements for post-high-school education, by far the largest number work for employers whose minimum requirement is graduation from a technical institute or a technical program in a community college. For 8 percent of all technical workers the requirement is college graduation (4 or more years). Some college or technical institute attendance, though not graduation, is required for another 8 percent of the total, while apprenticeship or armed-forces technical school graduation is specified for 3 percent. This is seen in the following distribution of the persons working in technical occupations among employers who require various levels and types of education.

Education required	*Number*	*Percent distribution*
All levels	148,684	100.0
Post-high-school	69,554	46.8
Engineering college	5,788	3.9
Graduation	2,200	1.5
Less than graduation	3,588	2.4
College, general	14,017	9.4
Graduation	9,702	6.5
Less than graduation	4,315	2.9
Technical institute (including technical program in community college)	34,574	23.3
Graduation	30,803	20.8
Less than graduation	3,771	2.5
Type not specified	10,563	7.1
Apprenticeship or armed forces school	4,612	3.1
High school	79,130	53.2
Technical or vocational	11,376	7.7
Other	67,754	45.5

There are wide differences among the technical occupations in respect to employers' minimum educational requirements. Some kind of post-high-school education is required for 81 percent of the personnel in the mathematics technician group. From there the proportion ranges down to 4 percent in the case of product testing and inspection specialists. (The airway group is a special case; see page 46.)

Technical occupation group	*Number in occupation*	*Post-high-school percent*
All occupations	148,684	46.8
Mathematics technicians	831	81.2
Data-processing systems analysis and programming specialists	6,153	68.1
Technical writing and illustration specialists	3,034	64.9
Broadcasting, motion picture, and recording studio specialists	2,920	62.3
Physical science technicians	8,969	62.1
Structural design technicians and related specialists	2,516	56.4
Electro and mechanical engineering technicians	42,031	56.2
Sales and service technicians	1,932	53.8
Biological, medical, dental, and related science technicians	25,445	51.7
Industrial engineering technicians and related specialists	6,901	45.0
Draftsmen	20,972	40.0
Civil engineering and construction technicians and specialists	13,464	27.2
Safety and sanitation inspectors and related specialists	4,084	14.6
Product testing and inspection specialists	8,059	4.1
Airway tower specialists and flight dispatchers	1,373	2.3

(The chapters of volume 2 present survey findings on educational and experience requirements and preferences for individual occupations included in each of the groups in the above list.)

The proportion of workers for whom employers require some post-high-school education rises from 46.8 to 51.6 percent if government is excluded. This difference is explained by the fact that the federal government has an unusually liberal policy of allowing job applicants to substitute experience for education.

Many employers who said they required high-school education stated that they preferred to have some amount of post-high-school education in addition. As compared to 47 percent on a required basis, 65 percent of personnel in technical occupations work for employers who prefer some post-high-school education. Thus, technical-institute graduation goes from 21 percent on a required basis to 31 percent on a preferred basis; college graduation, from 8 to 17 percent.

Employers' requirement of or preference for education beyond high school reflects not only a need for more extensive training but also, in some instances, the desire to employ older, more mature individuals.

It may be asked why college graduation (4 or more years) is recognized as an educational requirement for technical occupations in view of the fact that technical occupations generally are supposed to be at a subprofessional level that does not require college graduation. The answer is that for most technical occupations at least a few employers require college graduation, even though a majority do not. Also, as previously indicated, there are certain jobs on the margin between technical and professional that were included in the survey as a unit; that is, all personnel in these jobs were included regardless of whether or not they were professional or subprofessional. (Page 45.)

Experience

About two-thirds of the employers, covering almost three-quarters of the workers in technical occupations, require some work experience as a condition of employment at the minimum acceptable level of educational attainment. The kind of work experience required usually is related to the job to be performed—work that helps develop relevant technical skills, knowledge of engineering, science, or technology, or knowledge of the company's products, equipment, or processes. In simpler kinds of technical work, only general work experience may be required. A general value of work experience is the evidence it affords of the applicant's work habits and capacities.

The average (median) number of years of experience required by employers for all their technical occupations is 2.3 years. The average is greatest for supervisory grades and typically decreases with decreases in grade level. There is a somewhat stronger relationship between grade steps and years of experience than there is between grade steps and amount of education required.

The number of years of experience required of applicants for technical jobs is related to the level of education required for these positions. Although there are exceptions in some occupations, the general rule holds that the less the education required, the more the experience required. Among employers reporting that some education beyond high school is a prerequisite for employment, the average experience required is around 1.4 years, over-all, while among those willing to accept persons with only high-school education the experience required is 2.9 years on the average. Accordingly, it appears that on the average, for all grade levels of technical occupations, post-high-school education is considered equivalent to about a year and a half of work experience. (Pages 47-50.)

For work in the beginning grades, around 2 years of work experience is required for the high-school graduate on the average, with a year or less needed where post-high-school education is required. (Table 43.)

About 27 percent of the persons in technical occupations work for employers who require no previous work experience as a condition of employment. This is more likely to be true of employers requiring some post-high-school education.

Many employers indicated that if they had a choice they would give up experience for more education. However, a substantial proportion indicated that they believed the values of work experience could not be replaced by school course work. They referred particularly to familiarity with the company's products, equipment, processes, production techniques; and to the fact that the work was too new, varied, changing, or complex to be covered adequately in the schools.

In addition to educational and experience requirements, a license, permit, or accreditation of some sort, or successful completion of a formal-type test, was required as a condition of employment in some companies. A government license or permit was required in the case of 5 percent of the workers in technical occupations; civil service examination in 8 percent; professional society accreditation in about 1 percent; and formal company test in 12 percent.

Why bother to go on studying after high school if employers on the average consider one to two years of work experience to be the equivalent of post-high-school education as a qualification for work in technical occupations? A young person looking forward to this kind of work might appropriately ask this question. By choosing work experience it is possible that he can not only earn an income but save the expense of going to school. These are immediate, concrete advantages.

On the other hand, a youngster would be ill-advised to disregard considerations on the other side of the argument: There is no assurance that he will find a job that will give him the kind of experience employers will equate with post-high-school education. His chances of promotion up the technical-occupation ladder are better if he has had post-high-school education. In a situation where there are more applicants than jobs, the person with post-high-school education has a better chance of getting the job, everything else being equal.

To some extent the advantages that technical workers draw from post-high-school training are shared by graduates of high-school technical programs. A number of public high schools offer courses in the subject matter with which technicians and technical specialists are concerned, and the returns of the survey suggest that employers think well of these programs. Employers reported that they required substantially less work experience of graduates of technical programs than they did of graduates of other high-school programs. Generally speaking, high-school technical-program graduates compare favorably with workers from post-high-school education programs, so far as years of work experience required by employers are concerned. (Pages 50-51.)

College and technical-institute graduation

How much education beyond high school do workers employed in technical occupations actually have? It was not feasible in the present survey to obtain comprehensive information of this kind, but it is estimated that 60 percent or more of these technical workers had had some kind of education beyond high school (the proportion varied a good deal among the different occupation groups).

Specific data were obtained on how many of these workers were college graduates and technical-institute graduates (including graduates of technical programs in community colleges). Employers reported that 29 percent of their employees in technical occupations were technical-institute graduates and that 13 percent were college graduates. The proportions were somewhat greater at higher-grade levels than lower ones. They varied from a total (college and technical institute combined) of 68 percent for data-processing analysts and programmers to 12 percent for product testing and inspection specialists. (Pages 41-42.)

Actual educational attainment, as measured by college and technical-institute graduation, is at a higher level than the minimum educational requirements that employers have established for the jobs; but it is lower than their educational preferences. (Page 47.)

Recruitment and Upgrading

Of the two methods employers have to obtain qualified workers in technical occupations, recruitment from outside the establishment was more often used than upgrading of existing employees. About 57 percent of workers were obtained by recruitment, during the two-year period preceding the survey (or other current period that the employer considered more representative). Of the other 43 percent, who were upgraded, only a few had had organized training:

Both methods	100.0%
Recruitment	57.4
Upgrading, total	42.6
With organized training	5.8
Without organized training	36.8

Upgrading, as might be expected, was the predominant method of obtaining workers in upper grades of technical occupations having multi-grade structures. It was the most usual method in several technical occupation groups, including electro and mechanical engineering technicians, and the industrial engineering, product testing and inspection, and among airway tower specialist groups.

Industries that in general rely heavily on outside recruitment tend to have a large proportion of small establishments. (Page 41.)

Employer' Views Concerning Education of Technicians

Interviews of a sample of approximately 1000 employers (excluding government and medical service) brought out some general viewpoints concerning the training of engineering and science technicians.

(1) On the question of the relative emphasis that should be placed on specialized work in technologies as compared with basic education in mathematics, science, engineering principles, and English and social studies, somewhat more than half the respondents said that basic education should have the emphasis. Around 28 percent stressed the need for specialization, and 20 percent indicated that there should be a balance between the two.

There was, however, a significant difference between the replies of small and large employers in this respect. Relatively more small employers emphasized specialization in technologies while relatively more large employers emphasized basic education. It seems evident that fewer small employers than large ones believe they can give specialized training, so that smaller firms tend to look to the school to do so. (Pages 69-70.)

(2) The responding employers were about equally divided between those who thought that high schools and institutes were doing a good job in meeting their needs for technical jobs and those who said they could do a better job.

Suggestions concerning how a better job might be done centered on (a) improving the qualities and general abilities of the students (dependability, work habits, ability to write reports, ability in verbal expression, desire to get ahead, etc.); (b) improving the content of the educational program (better grounding in English, improved background in mathematics and science, updating of technical courses, etc.); and (c) bringing about better cooperation between the schools and industry (guiding students to opportunities for technician employment, better communication concerning employers' needs, etc.).

Time and again employers stressed the importance of improving the work habits and other general qualities of students and of enhancing their educational background in English, mathematics, and science. (Page 69.)

(3) Over half the responding employers said that they did not recruit or obtain technicians from high schools or institutes (including community colleges). The intent of this inquiry was to find out the extent of direct recruiting, and the response confirms the impressions of the interviewers that communication between the schools and institutes and industry was not nearly as great as it might be. (For further detail about employers' views on technician education, see pages 68-70.)

Subject Knowledge and Technical Skills

As to specifically what kind of subject-matter knowledge is needed to perform technical occupation jobs, the information reported by employers falls into three groups: Subject knowledge generally needed, needed in a substantial proportion of cases, and needed occasionally.

Subjects most often reported as generally needed are general physics, technical drawing, and mathematics through trigonometry. Next in frequency with which reported as generally needed are general chemistry, basic electricity, basic electronics, advanced algebra, instrumentation, and mechanics and strength of materials.

Calculus, metallurgy, and various specific technologies were reported rather often as needed in a substantial proportion of cases or as needed occasionally, but they did not appear with much frequency under the heading of "generally needed."

Most frequently reported among the technical skills needed to perform technical jobs were abilities to use the following kinds of equipment or reference materials: blueprints and schematics, technical manuals and handbooks, hand and power tools, slide rules and desk calculators, drafting instruments, laboratory glassware and equipment, mechanical, electrical and electronic measuring instruments. (See pages 52-54 of this volume and, for detail on subject knowledge and technical skills, the various chapters of volume 2.)

Employer Training

Relatively few employers engage in organized training in technical occupations. Organized on-job training was found in about 6 percent of the establishments and tuition-refund programs in 9 percent. One or the other or both were found in 12 percent. A far higher proportion of large establishments have on-job training or tuition-refund programs than small ones.

Probably not more than 10 percent of all workers going into entry-level or higher grades of technical jobs in 1962 participated in training programs organized by employers to help qualify them for these jobs.

Utilization of Technicians

An attempt was made in the survey to ascertain how far employers go in the use of technicians to assist and support professional engineering personnel. Field interviewers asked employers about their policies and views in this connection; and ratios of technicians to engineers and scientists were computed to measure utilization in a quantitative manner.

Engineers and Scientists

Over-all, the survey found 142,732 engineers, scientists, architects, and mathematicians, and teachers of these subjects, employed in the State. They were divided as follows:

Engineers and architects	86,393	
Engineers		82,442
Architects		3,951
Scientists and mathematicians	21,123	
Scientists		19,321
Mathematicians		1,802
College teachers	17,865	
Engineering and architecture		2,834
Science and mathematics		12,228
Technology		2,803
High school teachers (licensed)	17,351	
Science		8,354
Mathematics		8,747
Technology		250

These figures exclude medical and dental practitioners as such, high school vocational and industrial arts teachers, and graduate students engaged in part-time research or teaching.

Electrical and electronic engineering lead all the other professional occupations in this list in terms of employment; they account for 18 percent of all engineers, architects, scientists, mathematicians, and teachers. Next largest is mechanical engineering and then civil and construction engineering. Chemists, the largest group of scientists, constitute 7 percent of the total.

Industry-wise, the largest employers of engineers and scientists are manufacturing, government, private colleges and schools, and private research laboratories and engineering services.

Of the total of 142,732 engineers, scientists, and teachers of these subjects, including architects and mathematicians, 124,511, or 87.2 percent, were reported as having an engineering degree, architecture degree, or a bachelor of science or higher science degree. An additional 2,700 or so were reported as having a bachelor or higher degree not in engineering or science. The remainder, about 15,500, or 11 percent, were reported as having no four-year college or higher degree. (Pages 63-64.)

Employers' views

The line drawn in the survey between engineers and scientists, on the one hand, and technicians on the other, reflects the distinctions that employers themselves made between these groups of employees. Employers were asked to base the distinction on kind of work performed rather than degrees or lack of degrees. It was the intention to exclude from the professional category persons with engineering or science degrees who at the time of the survey were working at the subprofessional level as technicians; and to include in the professional category persons without degrees who actually were working in the capacity of engineer, scientist, or the like.

In making the distinction among their employees, the majority of the employers responding stressed the point that engineers and scientists did the original work of creating, initiating, planning, designing, and high-level problem solving, while the technicians carried out their ideas and plans. Theoretical versus practical work, complex versus less complex subject matter, data evaluation and interpretation versus data organization and calculation, wide range versus narrow range of subjects dealt with, supervisory versus nonsupervisory responsibilities, were the other kinds of distinctions that employers stressed.

The vast majority of responding employers said "No" to the question whether any engineers were assigned to technician work because there was not an adequate supply of technicians.

The majority also said "No" to the question whether any technicians were doing work formerly performed by engineers. Of those who said "Yes" to this question, design and development, drafting, and developing test procedures were most often mentioned.

Although a majority of responding employers answered this question in the negative, a substantial number—about a third—said that there were engineering functions that could be broken out and assigned to technicians. Most often reported as a reason the shift hadn't been made was lack of enough work for both engineers and technicians. The smallness of the establishment was sometimes mentioned in this connection. A shortage of qualified technicians and the effort that would be required in training were reported in a significant number of cases. Some employers preferred to assign technician work to junior engineers in training. Some feared that maximum use of technicians with minimum use of engineers would endanger their capacity to take advantage of new business opportunities. (Pages 67-68.)

Technician-engineer ratios

The ratio of technician to engineer and scientist employment has been used as a measure of the effectiveness with which employers utilize technical manpower. A firm whose ratio is much lower than that of other firms may be under-utilizing technical manpower.

Taking all technicians and technical specialists, as defined in the present survey, and comparing their number with the total number of engineers and scientists employed (excluding high-school teachers) gives a ratio of 1.19 to 1, that is, 119 technicians and specialists for every 100 engineers and scientists.

A gross measure of this sort leaves much to be desired as a measure of the extent to which engineering and scientific functions are turned over to technicians. One reason is that the majority of establishments—mostly small ones—either have technical-level workers but no professionals, or have professionals but no technical workers. (Pages 16-17 and 71-72.)

Various other ratios refine the measurement by excluding technical specialists whose jobs are largely unrelated to the work performed by engineers and scientists, and by narrowing the comparison in other ways.

Fourteen special ratios of this kind show relationships ranging from 34 technicians to 100 engineers and/or scientists up to a ratio of 150 to 100. For example, the ratio is 58 to 100 when the number of engineering technicians engaged in design and development work is compared to the number of electrical, electronic, mechanical, and aeronautical engineers.

If the average (median) establishment ratio were taken as a standard for measuring optimum utilization and if all establishment ratios below were raised to this point, there would be an increase of roughly between 5 and 15 percent in the number of technicians employed —depending on which of the fourteen ratios is used as a measure. The increases would range from about 25 percent to 40 percent if the standard were set at the third quartile (the three-quarters point within the ratios of separate establishments). (Pages 74-75.)

Vacancies

Technical occupations, along with engineering and science occupations, are key groups of jobs in our industrial economy, training for which must be high on the State's list of educational priorities. They represent a problem because they require unusually long education and training time; also because they are among the occupations for which manpower needs are expected to expand most rapidly during the next decade.

No widespread and acute shortages of technicians and technical specialists, however, were encountered in the survey. This finding came as a surprise to many of the consultants employed on the survey.

This does not mean that shortages do not exist. Employers reported some 4,500 vacancies in technical occupations in 1962, a number equal to 3 percent of all workers in these occupations. In most technical occupations, government agencies have the highest, or among the highest, vacancy rate of all employers.

Electro and mechanical engineering technicians account for 31 percent of all vacancies; within this group, vacancies in the electronics and electro-mechanical fields are relatively large in number, notably in the computer and instrumentation fields. Biological, medical, dental, and related technicians account for nearly 23 percent of the total; therapists and biological and medical laboratory technicians stand out; the public health field has an unusually high vacancy rate. Architectural and structural draftsmen and civil engineering and construction technicians also account for substantial proportions of the total number of vacancies. A relatively high vacancy rate is reported for data-processing programmers.

In occupations with two or more grades, the vacancy rate in the lowest grades (3.5) is almost twice that for the highest grade (1.9). (Pages 36-39.)

Conclusions

(1) One of the main conclusions to be drawn from the present survey is that in technical occupations we are dealing with a field of great diversity—in the kinds of jobs performed, in the types of industry where they are found, in requirements of employers for education and experience. Literally hundreds of different occupations may be distinguished, no one of overshadowing importance.

(2) Although there is a large number of different technical occupations, they do not, however, employ many workers—do not represent a large demand for manpower or a field of many employment opportunities. Technical occupations include 2.5 percent of the employed labor force in New York State; and even when professional engineers and scientists are added, the combined number does not come to over 5 percent of the employed labor force. Despite the large growth that is expected to take place in the State in the next ten years, the combined number will fall considerably short of 10 percent at the end of the ten years.

(3) There are a number of practical difficulties in employing technicians to take over some traditional engineering and scientific functions; and the extent to which such substitution now exists and has existed in the past is less than is generally supposed.

(4) These technical jobs, nevertheless, are critical to the industrial economy. They are a principal way the economy has adjusted to a supply of engineers and scientists that has been limited in relation to technical manpower needs.

(5) As the pace of automation technology quickens, some increase in technician-engineering ratios may be expected, especially in the design and development of electronic, electrical, and mechanical instruments and equipment. The physical science, medical, and construction fields also may be singled out as ones in which technicians and technologists are playing an increasing role.

(6) Both high schools and post-high-school institutions have had a role in educating for technical occupations. Persons with no more than a high-school education have found a place in virtually all these occupations. Such a person has a pretty good chance of getting a job in most technical occupations if he is intelligent, dependable, and well-motivated, has a good high-school mathematics and science background, and has work experience contributing technical skills and know-how. A young person's chances of getting a job are improved, however, if he has had substantial post-high-school technical education, and especially if he has an associate or higher degree.

Employers who have had experience with the technical curriculums offered by some high schools tend to think well of them. If more widely available and better known, such curriculums might help overcome the preference that some employers have for technical education in post-high-school institutions.

(7) Some support can be found in the viewpoints of large employers for the position that educational institutions should place primary emphasis on education in mathematics, science, the basic technologies, and English and other humanities, leaving to industry the task of training in special segments of technology needed to perform technical jobs. Large employers have stepped in and organized their own training where there has been a lack of training in the schools or where the schools have been unable in their instruction to keep up with technological developments. On the whole, however, industry has not found it necessary to engage in widespread formal training of technical personnel; this is explained not only by the fact that many educational institutions are doing a good job in this field, but also by the fact that on-job experience has significant training and educational values even when unaccompanied by formal instruction.

Small employers are much more likely than large ones to recruit technical personnel in the open market. In doing so they may profit from training their new workers have previously had in large firms.

(8) Conclusions concerning subject-matter curriculums in the technical occupation field are beyond the scope of this report. The fifteen chapters of volume 2, on the fifteen broad types of technical occupations studied, present findings as to subject-matter and technical-skill needs that are pertinent to the problems of curriculum development. The need for better communication between the schools and industry in this connection is referred to at various points in the report.

(For projections of technical occupation jobs the reader should refer to supplement B to volume 1.)

I. INTRODUCTION

The term "technician" has been widely used in industry and government; it, as well as the term "engineering technician," is commonly applied to persons who combine some scientific or engineering knowledge with technical skill in assisting or supporting engineering activities, and who work in the occupational area between the craftsman and the engineer. But there has not been any comprehensive delineation of what specific occupations fall within the scope of this definition.[1] Moreover, the definition is too limited, for there are many technical-type occupations that are left outside it.

SCOPE OF TECHNICAL OCCUPATIONS

The New York State Labor Department, with the advice of the New York State Department of Education and the State University, decided, first, that the scope of the survey should be broadly defined—to include all technical occupations not falling into a craft, management, professional engineering, or professional science category; and second, that technical occupations should be included within the survey's scope whether or not they required a particular level of formal schooling.

The term "technician" was abandoned as a characterization of the kinds of job covered, in favor of the more inclusive term "technical occupation." It was expected that "engineering technician" would be just one of the distinguishable groups of technical occupations.

The term "technical occupation" was defined and explained as follows in Survey Schedule A, a questionnaire mailed to all employers in the survey sample:[2]

Definition

For present purposes a technical occupation is defined as one which requires knowledge of scientific, engineering, or mathematical principles and which involves a task of applying these principles to the solution of problems or to the performance of particular functions or operations. The task usually includes some kind of analysis, designing, drafting, testing, technical writing, or related duties.

Explanation

(A) Technical occupations as here defined include the jobs of:

(1) Persons who provide direct support to the engineer, scientist, mathematician, or architect in specialized areas of their work.

(2) Technical specialists engaged directly in production, distribution, medical and dental services, and related processes and services.

(3) Supervisors working in a nonprofessional capacity who perform technical functions for a substantial proportion of their time or who are immediately responsible for directing technical work.

(4) Any graduate engineers, scientists, mathematicians, or architects who are in fact assigned to technical occupations. However, such professionally trained persons should not be reported simply because they are temporarily assigned to the easier tasks in the "breaking-in" or trainee stages of a professional job.

(B) Technical occupations as here defined exclude the jobs of:

(1) Persons engaged in unskilled or semiskilled work, even though such work involves the use of technical apparatus and equipment. Simple, repetitive testing and inspection, for example, is likely to be an unskilled or semiskilled operation.

(2) Persons engaged in traditional craft operations, such as machinist, tool and die maker, electrician, and cabinet maker. However, persons using craft skills should be reported if their work requires that they regularly devote two-thirds or more of their time to carrying out technical functions and less than one-third to applying craft skills.

In addition to this explanation of what was meant by a technical occupation, Schedule A listed examples of various kinds of technical occupation. In filling out Schedule A, employers were guided both by the over-all definition and by the examples. Most of them listed their own titles without including job descriptions (although they had been requested to do so).

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[1] Certain specific engineering and science technician occupations are well described in U.S. Department of Labor, Bureau of Employment Security, *Technical Occupations in Research, Design and Development Considered as Supporting to Engineers and Physical Scientists* (February 1961). Also see Instrument Society of America, *The Instrumentation Technician* (April 1961).

[2] A copy of this and other schedules used in the survey will be sent on request. Address: Division of Research and Statistics, New York State Department of Labor, 80 Centre Street, New York, New York, 10013.

Members of the survey staff visited those employers who on Schedule A reported workers in technical occupations. These visits obtained information on employment and related matters (as called for in Survey Schedule B1), and job descriptions, how much schooling and/or experience the employer required, and what subjects the technician needed to know (as called for in Schedule B2). At the same time it was ascertained whether, on the one hand, the employer's listing of technical occupations was incomplete, or, on the other hand, included occupations that did not fit into the survey's concept of "technical."

Employers reporting no technical occupations in response to Schedule A were visited or called by phone if they had the kind and size of business that sometimes employed technical personnel.

DISTINGUISHING TECHNICAL FROM NONTECHNICAL

Technical occupations as defined embrace a wide variety of responsibilities requiring widely varying skills and kinds of knowledge. They include both the kind of technician who works very closely with an engineer or a scientist and shares some of his responsibilities, and the specialist with a limited amount of "know-how" in a shop or government agency. This means that technical occupations shade off into semiskilled and craft occupations at one end of the scale and into engineering and scientific jobs at the other end.

(1) To distinguish a technical occupation from a semiskilled occupation, the following minimum qualifications were established:

(a) It must be an occupation that requires—

a mathematics course beyond beginning high-school algebra,

and a science or technology course in any subject field beyond the beginning high-school course in that field.

Or (b) It must be an occupation that involves the use of technical equipment or procedures that require more than three months of normal (not crash) on-job training to teach a person of average intelligence having no related training and no substantial technical or scientific education.

Border-line cases were found primarily among product testers and inspectors, for the jobs in this group range from analyzing and interpreting data derived from a variety of instruments to the repetitive, routine operation of test equipment.

(2) Craft and similar skilled occupations were excluded even when they required more training than some lower-scale technical jobs (such as product testing).

If the worker performed both the manipulative, machine, and tool skills of the craftsman and the analytical responsibilities characteristic of the technician, his job was classified as a technical one if carrying out technical functions was the predominant work (interpreted to mean two-thirds or more of the incumbent's time).

The distinction between technical functions and craft skills was difficult to draw in a number of kinds of maintenance, installation, assembly, troubleshooting, and inspection work. Because of this problem, the following guide lines were drawn:

. . Installation, assembly, or disassembly of equipment and building or rebuilding that do not involve analysis of functions and which follow a blueprint or specific instructions were considered to be craft (or assembly) rather than technical functions.

. . Repair and maintenance of components or parts that is generally repetitive once mastered, and which ordinarily is done as benchwork, was deemed to be a mechanical rather than a technical function.

. . Generally, assembly, installation, and maintenance operations for which recognized trade, craft, or manual-labor experience and knowledge was a paramount requirement were excluded from "technical occupations."

. . Inspectors and troubleshooters were considered to be craftsmen and therefore excluded if the knowledge and skills which they had to have for their present job were essentially what the average experienced craftsmen in the field was expected to have for proficient operation. But if the job required knowledge of technology or technical procedures beyond this, and especially if it required additional knowledge in mathematics, science, or technology, or extraordinarily long or varied experience with the company's products or processes, the job was considered technical in nature.

. . Unless there was clear evidence to the contrary, electronic and other instrumentation troubleshooters (other than radio and TV repairmen) were classified as technicians, since theirs are not well-established craft disciplines.

. . A production foreman or supervisor of craftsmen or other workers not in technical occupations was excluded from the survey unless it was clear that in addition to such supervision he performed technical work of the kind covered by the survey for a substantial part of his time.

(3) The line between the technician and the engineer also was often difficult to draw. The difficulty was especially great in the case of design work. Many employers had no classification scheme that clearly separated engineering technicians from nongraduate engineers. In such cases several questions were asked to help guide employers in making the distinction:

(a) As to the employee's market status: Could he get a job in another company as an engineer?
(b) As to the employee's functions: Does he do original engineering work (e.g., design work)? Work that constantly calls for exercise of independent judgment? Work that stresses theory rather than application? Does he do more than one distinctly

different phase of an engineer's work? Could he work effectively in another field of his specialty? Does he work under the supervision and direction of an engineer or does he work independently? Generally, does he have multiple, highly difficult, and important responsibilities?

(c) As to education and training: Is he doing the sort of work that could be learned in a good two-year or three-year technical institute? Or is he doing much more than a typical graduate of such an institute might do even with four or five years of job experience?

(d) If he has had no protracted technical education, is he a person of highly exceptional ability? Or has he had ten or twelve years experience in a highly technical capacity?

Employers who employed both engineers and engineering technicians were asked to describe the basis on which they distinguished the two. They replied that, apart from the possession of an engineering degree, the principal difference was the degree of responsibility and of creativity required for the job. Typically, employers think of engineers as creative thinkers working on highly theoretical or complex problems; as the initiators of original designs; or as the developers of new methods and techniques. They are pictured as doing the over-all planning of a project and are expected to assume supervisory, executive, or administrative responsibility for it with a minimum of guidance. Technicians, on the other hand, often are described as specialists in a narrow field or as support personnel for engineers, who assist within specified limits in developing the ideas or designs of engineers or in developing one or more phases of a project. They are expected to handle the more routine and detailed aspects of the work and the aspects that require manual skills. (See pages 66-67.)

(4) After these criteria had been applied, a number of jobs were found to be on the margin as far as their classification as "technical" was concerned. As to some of these, the decision was made to include the entire job, even though its content varied considerably from firm to firm (for example, all data-processing programmers were included, even though the work of some programmers could be called professional, particularly that of scientific programmers). In other cases it was decided to exclude the entire job.

Borderline Jobs Completely Included

Jobs that may have professional status in some establishments:

- Data-processing programmers
- Data-processing systems analysts
- Medical record librarians
- Medical "technologists"
- Technical writers and illustrators
- Therapists

Jobs that may have craft or lower status in some establishments:

- Dental mechanics
- Industrial safety, building, and sanitation inspectors
- Loftsmen

Borderline Jobs Completely Excluded

- Aircraft pilots, flight engineers, navigators, and other flight personnel
- Apparel, textile, and related designers
- Criminal identification occupations[1]
- Dieticians
- Embalmers and undertakers
- Photographers
- Psychology aides
- Radio and TV repairmen
- Radio operators
- Registered nurses
- Rodmen and chainmen
- Actuarial aides
- Tracers and inkers
- Central control operators in production processes (for example: electric power station operators; railway remote control center operators; monitors and operators of control centers in chemical, petroleum, steel, paper and pulp, and related manufacturing processes)

ENGINEERS AND SCIENTISTS

In a secondary phase of the survey, firms were asked to report the number of persons they employed in the capacity of engineer, architect, scientist, mathematician, or teacher of subjects in those fields, assigning each to one of the following categories:

Engineers and architects	**Scientists and mathematicians**
Architects	Mathematicians
Aeronautical	Agricultural scientists
Air conditioning, heating, and refrigeration	Biological scientists
Chemical	Chemists
Civil and construction	Geologists and geophysicists
Electrical and electronic	Medical scientists (excluding medical practitioners)
Industrial	Metallurgists
Mechanical	Physicists
Metallurgical	Other (to be specified)
Other (to be specified)	

Persons were classified in the field occupying the greatest proportion of their time. Chapter VI of this volume tells how many were in each occupation. The whole group will hereafter be referred to as "engineers and scientists."

EXCLUSION OF SELF-EMPLOYED PERSONS

The survey took in most self-employed persons engaged in technical occupations who also employed other persons; but it was not feasible to include self-employed persons having no employees. This means that the number of persons in technical occupations is understated to some degree. The maximum extent of the understatement is suggested by the following 1960 Census data on groupings for which the total number of self-employed was reported by the Census. The first column gives the number of workers in the occupation in the State, and the second gives the proportion of these who are self-employed, whether or not they employed other persons. The information is given for engineers and scientists as well as for technical-level employees.

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[1] The following numbers of persons in criminal identification occupations were found in New York State, nearly all in the New York City government:

22 ballistic and firearm specialists
15 bomb specialists
13 crime scene specialists
4 Keeler polygraph experts
221 fingerprint and handwriting analysts
13 general

Clearcut criminal identification occupations of this sort were not generally found outside New York City. This fact, along with the fact that jobs were often only semi-technical in nature, led to the exclusion of these occupations from the survey, although originally it was intended to include them.

Occupation	*Total*	*Self-employed*
Technical workers:		
Medical and dental	14,760	7.3%
Electrical and electronic	12,283	0.5
Other engineering and physical science	17,487	0.4
Technicians not elsewhere classified	6,214	2.6
Draftsmen	23,187	1.3
Surveyors	2,345	8.0
Engineers	87,524	3.3
Aeronautical	3,818	0.1
Civil	15,354	4.8
Electrical	23,551	0.9
Mechanical	14,898	2.4
Other	29,903	5.2
Natural scientists	13,916	2.7
Chemists	9,680	2.6
Other	4,236	3.0

SAMPLING PROCEDURE USED IN SURVEY

The survey data were derived from a sample of 17,414 establishments located in New York State. These establishments accounted for 50.4 percent of the total employment of all businesses in New York State, exclusive of agriculture, domestic service, the military service, and the self-employed who employed no other persons.

For nongovernment establishments, a technique of stratified random sampling was used. All establishments of 500 or more employees, half of those with 100 to 499 employees, 10 percent of those with 20 to 99 employees, 2 percent of those with 4 to 19 employees, and 1 percent of those with 1 to 3 employees were included in the sample. Higher sampling ratios were used in industries in which large numbers of technicians and engineers were known to be employed. For example, all known research, engineering, and medical laboratories, and almost all hospitals were included. In manufacturing, higher sampling ratios were used in industries making durable goods than in those making nondurables. Smaller sampling ratios were used in such fields as real estate, retail trade, and personal service industries, where few persons are employed in technical occupations.

Persons in technical occupations employed by establishments included in the sample constituted almost 80 percent of the estimated total number of technical workers in the State. The sample included a similar proportion of engineers and scientists.

The number of establishments that failed to respond to the question whether they had technical occupations was negligible. Despite the good over-all response, a few respondents, among them certain large companies and universities, supplied incomplete information on the number and types of technical workers, engineers, and scientists. The survey staff, therefore, was required to fill in detail by estimating from such reference points as were supplied by these organizations.

Since the proportion of the "universe" included in the stratified sample differed from stratum to stratum, the sample was subdivided by industry, area, and size, and a weight was assigned to each of the resulting cells in proportion to its establishments' presence in the universe. These weights were generally the reciprocals of the sampling ratios, with slight adjustments for nonresponse.

The universe estimates of number of establishments and of employment by area, size, and industry had been made from data obtained from the records of the New York Labor Department's Division of Employment, supplemented for some industries by data from "County Business Patterns," which is based on the records of the OASDI (Social Security) system.

In the field of government, towns and villages were stratified by population size and a sample was selected from each stratum. Almost all the county and city governments and agencies and departments of the State government were included in the sample, and all federal agencies that employed technical personnel. Military personnel was excluded, but civilians employed at military installations were included.

Table 53 in supplement A to volume 1 presents, for the universe and for the sample, the data on the number of establishments and employers, and the number of scientists, engineers, and persons in technical occupations, by industry group; also the percent that the sample is of the universe in each case.

Because the figures shown in the tables are estimates based on samples, they are subject to sampling errors and therefore do not have absolute accuracy. Caution should be used especially with respect to small numbers set forth in the tables, because, in surveys based on samples, the characteristics or types that occur with small frequency are subject to relatively large sampling errors. Percentage-wise, a small number can be substantially off the mark; the true number, for example, could be 15 or 5 instead of the 10 reported, or 1 or 4 instead of the 2 reported. Moreover, a blank, meaning that no technical workers of a particular kind were found, is not conclusive: the sampling may have missed catching an establishment that employed the particular type of technician mentioned.

II. EMPLOYMENT IN TECHNICAL OCCUPATIONS

The survey revealed a multiplicity of technical employments, many of them sparsely populated. The report gives data for approximately 200 different technical occupations. They average about 750 employees per occupation.

Total employment in these technical occupations totaled 148,684 workers—2.4 percent of all workers in New York State in 1962. In aggregate, the technical group is much smaller than the skilled crafts, and is about the same size as the group of engineers, architects, scientists, mathematicians, and teachers of subjects in those fields (hereafter referred to as "engineers and scientists"):

Occupational group	*Number*	*Percent*
Total employment, New York State[a]	6,227,700	100.0
Technical occupations	148,700	2.4
Engineers and scientists	142,700	2.3
Skilled craftsmen (rough estimate)	850,000	13.6

[a] Excludes farm and domestic employees, persons in military service, and self-employed who employed no other persons.

ESTABLISHMENTS WITH TECHNICAL OCCUPATIONS

Most establishments in New York State have no employees in technical occupations.[1] About 14,600 reported having some in 1962—3.7 percent of a total of approximately 393,500 business and government establishments in New York State. A slightly smaller number, about 14,400, reported that they employed engineers or scientists or both. Many establishments were in both groups—as the following figures indicate:

Type of personnel	*Establishments employing specified type of personnel*	*Persons in technical occupations in such establishments*	*Engineers and scientists in such establishments*
Persons in technical occupations (total)	14,595	148,684	117,157
Engineers and scientists (total)	14,437	124,297	142,732
Persons in technical occupations, but no engineers or scientists	7,862	24,387	—
Engineers or scientists, but no persons in technical occupations	7,704	—	25,575
Both persons in technical occupations and engineers or scientists	6,733	124,297	117,157

There are no technical, engineering, or science occupations in the majority of establishments simply because the vast proportion of businesses and of government agencies are engaged in trade activities or in performing services of a nontechnical nature. Few establishments in retail trade, in the finance, insurance, and real estate groups, and in the personal service group employ personnel of this sort.

In only 13 out of about 60 industry groups do 25 percent or more of the establishments employ persons in technical occupations or as engineers or scientists. The proportion exceeds 50 percent only in ordnance and electrical-machinery manufacturing and in communication. Technical occupations are found in 25 percent or more of the establishments in five industries (over 50 percent only in ordnance and communication). See table B, and tables 1 and 2 in supplement A to volume 1.

In limited segments of industry, however, almost all establishments employ workers in technical occupations and/or engineers or scientists. Such employees are found in 92 percent of the engineering and architectural service offices; in 96 percent of the medical and dental laboratories and in 94 percent of the nongovernment hospitals; and in all but a few government hospitals. The reason that a small minority of establishments in such an industry employ no personnel of this kind is that the industry includes establishments that are merely clerical or sales offices of out-of-state firms, establishments that perform nontechnical services for the industry, and establishments whose technical work is performed by another branch of the parent organization or is contracted out (as in some small hospitals) to independent service organizations. In some industries

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[1] The term "establishment" as used here refers to a company, or a unit within a company, whose operations are confined to a single industry in a single area, as classified by the New York Department of Labor's Division of Employment.

Table B. Industry Groups Having a Relatively High Proportion of Establishments with Technical Occupations and/or Engineers or Scientists

Industry group	Establishments with technical occupations		Establishments with technical occupations and/or engineers or scientists	
	Number of such establishments as percent of all establishments	Persons in such occupations as percent of industry's total employment	Number of such establishments as percent of all establishments	Persons in such occupations as percent of industry's total employment
All industries	3.7	2.4	5.7	4.7
Selected industry groups[a]				
Ordnance and accessories (mfg.)	100.0	16.7	100.0	31.1
Communication	64.2	7.2	65.5	9.3
Electrical machinery and equipment (mfg.)	44.2	7.7	50.8	15.3
Medical and other health services	28.5	8.9	28.7	9.9
Government	27.2	2.4	31.0	6.1
Transportation equipment (mfg.)	22.2	8.7	39.1	14.2
Machinery, except electrical (mfg.)	21.9	6.1	36.2	10.8
Chemicals and allied products (mfg.)	21.5	4.4	45.6	12.7
Electric, gas, and sanitary services	21.1	4.3	21.7	6.7
Miscellaneous services	19.7	17.3	29.7	33.1
Primary metal industries (mfg.)	19.5	2.2	34.0	4.1
Petroleum refining and related industries (mfg.)	19.4	6.7	24.0	13.5
Railroad transportation	19.0	1.7	19.6	2.2
Heavy construction	16.8	3.2	44.1	8.2
Fabricated metal products (mfg.)	16.1	2.7	24.6	4.6
Air transportation	15.7	6.2	16.2	6.5
Instruments; photographic and optical goods (mfg.)	15.4	8.4	29.8	16.4
Private colleges and schools	4.3	3.3	35.9	18.0

[a] See tables 1 and 2 in supplement A to volume 1 for data on other industry groups.

where the proportion is low, these same factors account for its being low. Industries such as communication, public utilities, and rail and air transportation, which consist of relatively few firms with many branches in different locations, tend to centralize their technical service personnel in one branch; the result is that a large proportion of the establishments within the firm and within the industry employ no one in technical, engineering, or science occupations.

It was indicated earlier (1) that there were about 7,900 establishments that employed technicians or technical specialists but no engineers or scientists and (2) that there were about 7,700 that employed engineers or scientists but no technicians or specialists. Together these two groups account for a majority (seven out of ten) of the establishments that have one or both, and establishment size is the chief reason for this: in the first category about 75 percent of the establishments have fewer than 20 employees, and in the second category about 70 percent. In contrast, only about 30 percent of establishments employing both technicians or specialists and engineers or scientists have as few as 20 workers of all sorts.

In the first category (with technical occupations only) a large majority (about 60 percent) are offices of physicians and dentists and medical and dental laboratories. (Practicing physicians and dentists are not classified as scientists.) The rest are mainly small manufacturing plants employing tool designers or product testers, contractors in special trades and other small construction firms employing such technical specialists as estimators and specification writers, and offices of surveyors.

A number of special situations go far to explain why there are no technical-level workers in more than half the establishments that employ engineers or scientists. (a) Many small manufacturing and construction establishments do not have enough technical work to keep both an engineer and a technician fully occupied. (b) Many wholesale divisions of large equipment manufacturers and many wholesalers who sell machinery, equipment, chemicals, etc., to businesses employ engineers or scientists as salesmen. (c) The overwhelming majority of private colleges and schools, though they have teachers of science, engineering, or technology, do not employ technicians to assist them. (Student assistants were excluded from the survey.) (d) There are many small engineering and architectural consulting firms, whose members engage in professional-level work without needing anyone at the lower level.

Size of establishment is a significant factor in the employment of technical, engineering, and science personnel. Large establishments are more likely to have employees of this kind than small ones are. Establishments of 1,000 or more employees employ almost half

Table C. Establishments Having Technical Occupations and/or Engineers or Scientists Stated as Percent of Total Number of Establishments in Specified Industry By Size of Establishment

Size of establishment (number of employees)	All industries	Manufacturing	Construction	Transportation, etc.[a]	Private medical services	Research labs, etc.[b]	Private colleges and schools	Government	All other
All sizes	5.7	11.7	8.9	3.8	28.7	47.4	35.9	31.0	1.5
1- 19	3.8	5.0	4.8	1.0	26.9	44.6	29.7	9.0	1.1
20- 49	13.3	16.6	47.8	12.7	51.5	60.4	42.2	33.2	3.6
50- 99	26.3	25.7	66.8	20.6	76.6	75.2	56.4	48.2	7.4
100- 199	37.5	43.6	75.7	27.0	88.5	83.6	81.8	50.2	14.3
200- 499	52.6	65.4	81.5	29.7	100.0	93.8	83.3	64.4	25.7
500- 999	74.4	85.5	93.8	55.0	100.0	66.7	100.0	87.7	43.8
1,000-1,999	80.9	92.2	100.0	74.2	100.0	100.0	100.0	88.8	50.0
2,000-4,999	88.3	94.3	—	89.3	100.0	100.0	100.0	85.7	74.1
5,000 or more	97.3	100.0	—	100.0	—	—	100.0	96.6	90.9

[a] Transportation, communication, and public utilities.

[b] Research, development, and testing laboratories; engineering and architectural services; and business and management consulting services.

of the technical, engineering, and science workers in the State.

The relation of size of establishments to the use of such workers varies from industry to industry. For example, in the broad field of manufacturing, only 16 percent of the establishments with fewer than 50 employees have technical, engineering, or science workers—for the manager or working proprietor of a small factory may supply all the technical know-how needed. In contrast, 46 percent of the establishments with fewer than 50 employees have such workers in the group that embraces research laboratories, engineering and architectural services, and business and consulting services. If this group is narrowed by excluding the business and consulting services, the percent with such workers is even larger: in fact, for establishments with fewer than 20 employees the proportion is 89 percent; above that level, virtually every establishment has some. (See table C; further detail is in tables 3 and 4 in supplement A to volume 1.)

Research and development (R & D) activities utilize many technical, engineering, and science workers. There are 22,299 establishments with such workers; of these 4,133, or about 19 percent, either engage in R & D or are branches of organizations that conduct R & D in New York State. All establishments with technical, engineering, or science workers in the State, combined, have 2,886,541 employees of all kinds; the establishments with R & D employ 38 percent of this total. Altogether there are 291,416 technical, engineering, and science workers; the establishments with R & D employ 54 percent of them (not all of these are engaged in R & D work).

Parallel information for various industries will be found in table 5 in supplement A to volume 1. The following summary of that information shows that manufacturing is the industry division that has the largest proportion of establishments with R & D (43 percent). These contain 84 percent of the technical, engineering, and science personnel in the State's manufacturing industries. (See table below.)

Approximately 48 percent of all establishments employing persons in technical occupations or as engineers or scientists are located in New York City. An additional 18 percent are in the remainder of the New York Metropolitan area—11 percent in Nassau-Suffolk and 7 percent in Westchester. The largest concentration of such establishments Upstate is in the Buffalo area (8 percent).

The relative frequency of establishments employ-

Industry division	*Establishments with R & D*		
	Number of establishments	*Their total employment*	*Their technical, engineering, and science employment*
	(Percent of corresponding figure for all establishments with technical, engineering, or science personnel)		
All industries	18.5	37.8	54.3
Manufacturing	43.2	65.0	84.3
Construction	3.1	4.0	13.4
Transportation, communication, and public utilities	1.2	5.3	12.8
Private medical services	2.9	43.2	28.5
Research laboratories and engineering services[a]	20.0	48.8	43.1
Private colleges and schools	6.6	50.2	69.0
Government	15.0	28.5	35.5
All other	20.5	14.9	31.2

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[a] Includes architectural as well as engineering service enterprises; research, development, and testing laboratories; and business and management consulting services.

ing technical, engineering, or science workers is greatest in the Westchester, Syracuse, and Buffalo areas where slightly more than 8 percent of all establishments employ them. In New York City, the figure is under 5 percent, less than in any other area. (For further details, see table 6 in supplement A to volume 1.)

Before proceeding to examine in detail the variety of technical occupations, two observations concerning the data presented above are appropriate: *First,* the fact that employment in technical occupations and in engineering and science occupations is small relative to the total volume of employment should not obscure the fact that these are key groups of jobs in our industrial economy, training for which must be high on the State's list of educational priorities. They constitute a problem both because they involve unusually long education and training time and because they are among the occupations for which manpower needs are expected to expand most rapidly during the years ahead. These points are taken up elsewhere in this report.

Second, it has been suggested that the efficiency with which engineers are utilized is measured by the number of technicians employed per engineer or scientist. The data assembled by this study that shed light on this ratio are taken up in chapter VIII.

TYPES OF TECHNICAL OCCUPATION

Fifteen broad groups of technical occupations emerge from the survey. These main groupings divide into a number of subgroups (shown in table D) and these subgroups in turn break down into 195 separate technical occupations. Tables 8 and 9 in supplement A to volume 1 show the number of persons in each, not only for New York State as a whole, but also for each area and each industry division.[1]

The following are the fifteen broad groups (in the order in which they are catalogued in table D):

I. Draftsmen

Draftsmen are the third largest of the fifteen types of technical occupations. There are 20,972 of them; they account for 14 percent of the 148,684 persons found in all technical occupations. Mechanical draftsmen are the largest of the draftsman groups, but there are nearly as many architectural and structural draftsmen. Together these two groups account for about 60 percent of all draftsmen. Electro-mechanical draftsmen rank next in size. They are followed by draftsmen of electro (electrical and/or electronic) systems and components, and then by highway, street, map, and topographical draftsmen.

II. Structural design technicians and related specialists

These are technicians and specialists who assist

Table D. Distribution of Employees by Technical Occupation

Technical occupation group	Number	Percent
All technical occupations	*148,684*	*100.0*
I. *Draftsmen*	*20,972*	*14.1*
A. Architectural and structural	6,294	4.2
1. Construction	5,973	4.0
2. Aircraft and ship structures	321	0.2
B. Electrical-electronic	2,301	1.6
1. Construction	684	0.5
2. Other	1,617	1.1
C. Mechanical	6,526	4.4
1. Construction	1,020	0.7
2. Other	5,506	3.7
D. Electro-mechanical	3,767	2.5
1. Construction	211	0.1
2. Other	3,556	2.4
E. Highway, street, map, topographical, and related draftsmen	862	0.6
F. Plant layout	422	0.3
G. General and other	800	0.5
II. *Structural design technicians and related specialists*	*2,516*	*1.7*
A. Construction	2,004	1.3
B. Aircraft structure	427	0.3
C. Ship structure	85	0.1
III. *Electro and mechanical engineering technicians*	*42,031*	*28.3*
A. Classified by field	*42,031*	*28.3*
1. Electronic	10,791	7.3
2. Electrical	3,618	2.4
3. Electronic-electrical	5,176	3.5
4. Mechanical	8,461	5.7
5. Electro-mechanical	13,985	9.4
B. Classified by function	*42,031*	*28.3*
1. Design	7,689	5.2
2. Development	6,803	4.6
3. Combination: design and development	1,392	0.9
4. Installation	458	0.3
5. Troubleshooting and related functions	18,880	12.7
6. Combination of installing and troubleshooting	3,068	2.1
7. Combination: all functions	3,741	2.5
C. Classified by product or equipment worked on	*42,031*	*28.3*
1. Instruments and electronic and science laboratory equipment	23,090	15.5
a. Electronic equipment and instruments	15,845	10.6
b. Electronic-mechanical instruments	4,629	3.1
c. Mechanical instruments	1,470	1.0
d. Science laboratory equipment n.e.c.	1,146	0.8
2. Machinery, electrical and mechanical equipment	15,223	10.3
a. Electrical equipment	10,981	7.4

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[1] As to electro and mechanical engineering technicians, tables 8 and 9 show the number in each of six fields and the number in each of seven functions, and tables 12 and 13 give some additional breakdowns. Statewide employment for each of the 42 kinds of electro and mechanical engineering technicians (six fields in relation to seven functions) is shown in table III-1 at the end of volume 2's chapter III.

architects and engineers in designing structures—building construction, aircraft, and ship. They are a small group, 2,516 in number, accounting for 1.7 percent of all persons in technical occupations. Designers in construction include those engaged in architectural and structural design and also those who design the electrical and mechanical systems of buildings; plus those engaged in design of highways and streets, bridges, and related construction. Included with aircraft and ship-structure designers are a small number of loftsmen, who among other things are responsible for "proving" the designs.

III. Electro and mechanical engineering technicians

This is the largest of the technical occupation groups, with 42,031, or 28 percent of all persons employed in technical occupations in 1962. Generally speaking, these persons assist engineers in designing and developing new machines, equipment, systems, components, and products, and in carrying out complex tasks of installation, troubleshooting, and maintenance. As table D shows, the characteristics of these engineering technicians have been classified in three ways:

(A) *Field* of engineering knowledge used: mechanical, electrical, electronic, and combinations of these.

(B) Kind of *product or equipment worked on:* principally electronic and mechanical testing, control, and measuring instruments; electrical machinery and equipment; nonelectrical machinery and equipment; aircraft and missile parts and equipment; other vehicles and related equipment; and ordnance and explosives.

(C) Kind of *function* performed: design, development, installation, troubleshooting and related functions, and combinations of these.

IV. Mathematics technicians

This is a small group of some 800 technicians who assist engineers and scientists by making mathematical computations and analyses. Most of them are employed by firms producing aerospace equipment and engineering, laboratory, and scientific and research instruments and equipment.

V. Physical science technicians

Well over half the 8,969 physical science technicians are engaged in assisting scientists by some sort of chemical testing or analysis. In addition, there is a group of about 1,000 technicians in metallurgy, 760 in the fields of physics, radiation, and nuclear energy, and smaller numbers in meteorology, minerals and soil, and miscellaneous fields.

VI. Biological, medical, dental, and related science technicians

These constitute the second largest group of technical occupations; some 25,000 in number, they are about 17 percent of all persons in technical occupations. The largest subgroup consists of technicians and technologists engaged in medical laboratory testing and analysis. Dental hygienists and dentist's assistants are the next largest group. Specialists in operating X-ray machines and related equipment also form a large group. Dental laboratory ceramists and mechanics, therapists, technicians operating electrocardiograph, electroencephalograph, and other medical equipment,

Table D. Distribution of Employees by Technical occupation (*continued*)

Technical occupation group	Number	Percent
b. Nonelectrical machinery and other metal equipment	4,242	2.9
3. Transportation equipment, aircraft, and ordnance	3,372	2.3
a. Aircraft and missile parts and equipment n.e.c.	2,784	1.9
b. Transportation vehicles and equipment n.e.c.	508	0.3
c. Ordnance	80	0.1
4. Other products and equipment	346	0.2
D. Classified by field and function	*42,031*	*28.3*
1. Electronic	10,791	7.3
a. Design	489	0.3
b. Development	4,873	3.3
c. Troubleshooting and related	5,429	3.7
2. Electrical	8,794	5.9
a. Design	1,006	0.7
b. Development	2,497	1.7
c. Troubleshooting and related	5,291	3.5
3. Mechanical	8,461	5.7
a. Design	4,450	3.0
b. Development	2,092	1.4
c. Troubleshooting and related	1,919	1.3
4. Electro-mechanical	13,985	9.4
a. Design	1,744	1.2
b. Development	2,474	1.7
c. Troubleshooting and related	9,767	6.5
E. Classified by field and product or equipment worked on	*42,031*	*28.3*
1. Instruments and electronic and science laboratory equipment	23,090	15.5
a. Electronic	10,065	6.7
b. Electrical	2,352	1.6
c. Mechanical	2,618	1.8
d. Electro-mechanical	8,055	5.4
2. Machinery, electrical and mechanical equipment	15,223	10.3
a. Electronic	472	0.3
b. Electrical	5,497	3.7
c. Mechanical	4,709	3.2
d. Electro-mechanical	4,545	3.1
3. Transportation equipment, aircraft, and ordnance	3,372	2.3
a. Electronic	240	0.2
b. Electrical	930	0.6
c. Mechanical	934	0.6
d. Electro-mechanical	1,268	0.9
4. Other products and equipment	346	0.2
a. Electronic	14	*
b. Electrical	15	*
c. Mechanical	200	0.1
d. Electro-mechanical	117	0.1
F. Classified by function and product or equipment worked on	*42,031*	*28.3*
1. Instruments and electronic and science laboratory equipment	23,090	15.5
a. Design	2,729	1.8
b. Development	8,083	5.4
c. Troubleshooting and related	12,278	8.3

medical assistants in doctor's offices, and medical record librarians are smaller groups. Nurses were not considered to be technicians in this survey and so were excluded.

VII. Industrial engineering technicians and related specialists

The common denominator of the various activities classified in this sizeable group of 6,900 workers (about 5 percent of all persons in technical occupations) is concern for the efficiency, quality, and cost of the production process. Industrial engineering technicians—including time and motion study and standards men, methods men, and the industrial engineer's general assistants—account for about a third of the group total. About two-fifths of the total are specialists in planning, coordinating, expediting, estimating, standardizing, scheduling, and related activities. (Construction estimators are included in group VIII.) There were several hundred specialists in equipment procurement, maintenance and replacement procedures, and nearly 1,300 technicians concerned with reliability and quality-control methods.

VIII. Civil engineering and construction technicians and specialists

This is the fourth largest group of technical occupations, accounting for nearly 13,500 persons (9 percent of the total in all groups). The largest subgroups are civil engineering assistants and construction technicians such as construction superintendents. There are almost 2,400 surveyors and instrumentmen. Construction inspectors, most of whom are employed by state and local government agencies to enforce building code and safety standards, account for about 20 percent of the group total. Finally, there are 3,300 construction cost estimators and specifications writers.

IX. Sales and service technicians

These persons, about 1900 in number, service a company's sales department in the promotion and sales of technically complex products, serve as a source of information concerning the technical needs of customers, and assist customers in the installation, use, and maintenance of the company's products.

X. Technical writing and illustration specialists

The roughly 3,000 persons in this group divide up about two-thirds writers and one-third illustrators. Their function mainly is to translate highly technical information into simple factual language and drawings. They may be engaged in preparing production, operation, or maintenance manuals and handbooks, promotional and sales brochures and displays, and reports on technical developments for books and periodicals. The largest number are employed by publishers of books and periodicals.

XI. Safety and sanitation inspectors and related specialists

Over three-quarters of these 4,000 persons are inspectors employed by government agencies to enforce fire, safety, and health laws and codes. Most of the others are involved in industrial plant safety and health activities.

XII. Product testing and inspection specialists

These specialists inspect and test products to spot

Table D. Distribution of Employees by Technical occupation (*continued*)

Technical occupation group	Number	Percent
2. Machinery, electrical and mechanical equipment	15,223	10.3
a. Design	4,173	2.8
b. Development	2,933	2.0
c. Troubleshooting and related	8,117	5.5
3. Transportation equipment, aircraft, and ordnance	3,372	2.3
a. Design	517	0.3
b. Development	878	0.6
c. Troubleshooting and related	1,977	1.4
4. Other products and equipment	346	0.2
a. Design	270	0.2
b. Development	42	*
c. Troubleshooting and related	34	*
IV. *Mathematics technicians*	*831*	*0.6*
V. *Physical science technicians*	*8,969*	*6.0*
A. Chemical and related	5,162	3.4
B. Metallurgical and related	987	0.7
C. Physics-chemical	1,638	1.1
D. Physics, radiation, and nuclear	761	0.5
E. Meteorology	185	0.1
F. Minerals and soil	140	0.1
G. Other	96	0.1
VI. *Biological, medical, dental, and related science technicians*	*25,445*	*17.1*
A. Agricultural and related	340	0.2
B. Biological and medical laboratory	9,898	6.7
C. General medical assistants, doctor's office (other than nurse or secretary)	1,114	0.8
D. X-ray and related equipment technicians	3,013	2.0
E. Other medical technicians	1,801	1.2
F. Therapists	1,883	1.3
G. Medical record librarians	347	0.2
H. Dental laboratory technicians	2,844	1.9
I. Dental hygienists	1,874	1.3
J. Dental assistants	2,331	1.5
VII. *Industrial engineering technicians and related specialists*	*6,901*	*4.7*
A. Industrial engineering technicians	2,224	1.5
B. Quality control and reliability technicians	1,279	0.9
C. Production planners, estimators, and related specialists	2,918	2.0
D. Equipment specialists	480	0.3
VIII. *Civil engineering and construction technicians and specialists*	*13,464*	*9.1*
A. Surveyors and related specialists	2,381	1.6
B. Civil engineering and construction technicians	4,932	3.3
C. Construction inspectors	2,804	1.9
D. Construction specifications writers and cost estimators	3,347	2.3
IX. *Sales and service technicians*	*1,932*	*1.3*

defects. There are about 8,100 of them, and 85 percent are employed by manufacturing establishments. Their jobs vary a great deal in difficulty; some are close to being only semiskilled jobs. Many present-day testing and inspecting jobs are essentially routine and easily learned. A testing or inspecting job was not included in this technical occupation group unless it required at least three months of job training or some substantial technical or scientific course of instruction. On the other hand, if the amount of job training or technical or scientific training required ran well beyond a year's time, the job was likely to be classified in the electro and mechanical engineering technician group—or in the physical science technician category, especially if it was a laboratory operation.

The largest concentrations of testers and inspectors were in the electro instrument, industrial machinery, aircraft equipment, chemical, textile, food, construction material, and paper products groups.

XIII. Data-processing systems analysis and programming specialists

As was pointed out in the introductory section of this report, an effort was made to include all data processing systems analysts and programmers in the survey, even though some firms consider many of those in their employ to be professional workers. About 6,200 persons were found in these occupations; business and accounting programmers were the largest concentration.

XIV. Airway tower specialists and flight dispatchers

To carry out their responsibilities as aircraft flight control specialists, this relatively small group numbering about 1,400, require a range of knowledge in aviation, weather, navigation and communication procedures and equipment, and flight procedures. Nearly all the airway tower specialists are employed by the Federal Aviation Agency (a few are employed by aircraft manufacturing companies). Air transport companies employ flight dispatchers to coordinate flight schedules and to see that federal (FAA) and company flight and safety regulations are observed.

XV. Broadcasting, motion picture, and recording studio specialists

These are 2,900 specialists engaged in somewhat diverse activities in broadcasting, motion picture, and recording studios. A majority are audio, acoustics, video control, recording, and other studio technicians. Some 1,200 are equipment and maintenance technicians.

Though these fifteen groups of technical occupations are distinguishable, the work content of a number of them is related. Some overlap, others shade into each other. These relationships are indicated in the last two pages of this chapter.

The classification of technical occupations used in this report does not constitute a terminology that is generally used in industry; indeed, the survey found little standardization or common use of terms. However, a number of traditionally recognized occupations do appear among those identified in the survey; some common ones are listed in the adjacent column:

Table D. Distribution of Employees by Technical occupation (*continued*)

Technical occupation group	Number	Percent
X. *Technical writing and illustration specialists*	*3,034*	*2.0*
A. Technical writers and related specialists	1,906	1.3
B. Technical illustrators	1,082	0.7
C. General and other	46	[a]
XI. *Safety and sanitation inspectors and related specialists*	*4,084*	*2.7*
A. Industrial safety and fire prevention	2,253	1.5
B. Sanitation	1,771	1.2
C. Air safety	60	[a]
XII. *Product testing and inspection specialists*	*8,059*	*5.4*
A. Instruments, meters, and related equipment	2,335	1.6
B. Machinery, transportation and other metal equipment, and appliances n.e.c.	2,762	1.8
C. Chemical and other nonmetal products n.e.c.	1,926	1.3
D. Food and agricultural products	563	0.4
E. Industrial X-ray and related processes	308	0.2
F. General and other	165	0.1
XIII. *Data-processing systems analysis and programming specialists*	*6,153*	*4.1*
A. Systems analysts	1,875	1.3
B. Programmers	3,205	2.1
C. Combination: systems analysis and programming	936	0.6
D. Project planners	137	0.1
XIV. *Airway tower specialists and flight dispatchers*	*1,373*	*0.9*
XV. *Broadcasting, motion picture, and recording studio specialists*	*2,920*	*2.0*

[a] Less than 0.05 of a percent.

Occupation	*Number*
Draftsmen	20,972
Electronic and electrical technicians	19,585
Medical laboratory technicians	9,898
Chemical technicians	5,162
Technical writers and illustrators	3,034
Medical X-ray technicians	3,013
Construction cost estimators	2,898
Dental laboratory technicians	2,844
Tool and machine designers	2,762
Dental assistants	2,331
Safety inspectors	2,253
Dental hygienists	1,874
Surveyors	1,171

BASIS OF PAY

About 78 percent of the workers in technical occupations are salaried:

	Number	*Percent*
Total	148,684	100.0
Paid on hourly basis[a]	33,477	22.5
Paid on salaried basis[a]	115,207	77.5
Earning $2.00 or more an hour or $75 or more a week	143,207	96.3
Earning less than $2.00 an hour or $75 a week	5,477	3.7

[a]. Some employers did not report hourly and salaried workers separately. The 1,815 workers reported on a combined basis, of whom 174 earn less than $2.00 an hour, have been pro-rated in the table.

Product testers and inspectors are the group paid on an hourly basis most often.[1]

The survey questionnaire also asked how many technical occupation workers were paid less than $2.00 an hour or $75 a week. Of the 3.7 percent who were, about three-quarters were in the medical technician group or the product testing and inspection group. (See table 7 in supplement A to volume 1 for detail on basis of pay.)

INDUSTRY VARIATION IN TYPES OF TECHNICAL OCCUPATION

It is in the nature of most technical occupations that work content is directly related to kind of product, process, or equipment, and so the types of technical occupation employment vary greatly from one industry to another. To take an obvious example, nearly two-thirds of all biological, medical, dental, and related technicians are employed in hospitals and in other medical

Table E. Percent Distribution of Persons in Technical Occupations According to Industry Division, by Occupation Group

Technical occupation group	All industries	Manufacturing	Construction	Transportation, etc.[b]	Private medical services	Research laboratories, etc.[c]	Private colleges and schools	Government	All other
All technical occupations	100.0	39.7	5.1	9.5	11.1	9.9	2.5	14.2	8.0
Draftsmen	100.0	44.7	5.5	5.0	[a]	33.1	0.3	5.1	6.3
Structural design technicians and related specialists	100.0	19.7	13.1	3.3	—	53.2	0.2	5.0	5.5
Construction	100.0	3.4	16.4	4.0	—	65.7	0.2	3.4	6.9
Aircraft structure	100.0	100.0	—	—	—	—	—	—	—
Ship structure	100.0	—	—	3.5	—	29.4	—	67.1	—
Electro and mechanical engineering technicians	100.0	56.2	0.4	21.2	[a]	5.1	1.4	6.0	9.7
Electronic	100.0	72.7	[a]	3.6	[a]	6.5	1.4	9.7	6.1
Electrical	100.0	49.2	—	28.7	—	8.1	2.2	10.7	1.1
Electronic-electrical	100.0	34.1	—	49.4	—	0.9	0.9	12.8	1.9
Mechanical	100.0	76.8	1.8	4.5	0.1	6.6	3.2	2.6	4.4
Electro-mechanical	100.0	41.1	—	32.5	[a]	4.0	0.3	1.3	20.8
Mathematics technicians	100.0	74.8	—	—	0.1	17.2	6.7	1.2	—
Physical science technicians	100.0	75.4	0.1	1.4	0.1	6.1	7.2	6.2	3.5
Biological, medical, dental, and related science technicians	100.0	1.9	—	[a]	64.7	0.3	8.6	21.2	3.3
Industrial engineering technicians and related specialists	100.0	75.8	—	1.7	—	3.6	0.3	16.6	2.0
Civil engineering and construction technicians and specialists	100.0	1.0	42.9	4.9	—	15.6	0.1	34.4	1.1
Sales and service technicians	100.0	42.0	4.5	—	0.1	0.5	—	2.7	50.2
Technical writing and illustration specialists	100.0	72.5	—	1.2	—	20.3	0.4	2.6	3.0
Safety and sanitation inspectors and related specialists	100.0	6.6	0.2	0.4	[a]	0.7	[a]	79.3	12.8
Product testing and inspection specialists	100.0	85.0	0.1	1.0	—	4.2	—	7.7	2.0
Data-processing systems analysis and programming specialists	100.0	33.0	[a]	7.5	0.2	3.5	2.2	6.7	46.9
Airway tower specialists and flight dispatchers	100.0	1.6	—	16.6	—	—	—	81.8	—
Broadcasting, motion picture, and recording studio specialists	100.0	6.3	—	78.7	—	—	0.3	3.3	11.4

[a] Less than 0.05 of a percent.
[b] Transportation, communication, and public utilities.
[c] Research, development and testing laboratories; engineering and architectural services; and business and management consulting services.

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[1] Many persons in technical occupations are classified as "exempt" for purposes of Fair Labor Standards Act coverage. No determination was made in this survey of what proportion exempt workers are of all workers in technical occupations.

and dental services. Another obvious case is the construction industry, which employs about 6,000 civil engineering and construction technicians and specialists but few others in technical occupations.

Tables E and F (based on table 9 in supplement A to volume 1) show how various technical occupations are distributed among eight primary industry groups.

Taking all persons in technical occupations together, manufacturing industries employ by far the largest number—about 40 percent of the total. Government is the second largest employer, with 14 percent of the total; private medical services are third; research laboratories and architectural and engineering services are fourth; and transportation, communication, and public utilities fifth.

Government is the principal employer of several kinds of technicians and technical specialists. Government agencies employ over 90 percent of airway tower specialists, almost 80 percent of all safety and sanitation and related specialists, a third of the civil engineering and construction technicians and specialists, and a fifth of the biological and medical technicians.

The following private-industry divisions[1] account for 20 percent or more of the persons in the specified technical occupation groups:

Manufacturing: draftsmen; electro and mechanical engineering technicians; mathematics technicians; physical science technicians; industrial engineering and related technicians; sales and service technicians; technical writing and illustration specialists; product testing and inspection specialists; data-processing systems specialists.

Construction: civil engineering and construction technicians and specialists.

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[1] For the special purposes of this report, industry divisions are used that differ from the standard divisions in the following ways: (1) Two segments of the service industry are shown separately: (a) Private medical services and (b) Research, development, and testing laboratories, engineering and architectural services, and business and management consulting services. (2) The remainder of the service industry is included in "All other ndustries," as are the following standard industry divisions: mining; wholesale and retail trade; and finance, insurance, and real estate.

Table F. Percent Distribution of Persons in Technical Occupations According to Occupation Group, by Industry Division

Technical occupation group	All industries	Manufacturing	Construction	Transportation, etc.[b]	Private medical services	Research laboratories, etc.[c]	Private colleges and schools	Government	All other
All technical occupations: Number	148,684	59,085	7,523	14,084	16,496	14,749	3,754	21,063	11,930
Percent distribution									
All technical occupations: Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Draftsmen	14.1	15.8	15.5	7.5	[a]	46.9	1.8	5.1	11.1
Structural design technicians and related specialists	1.7	0.8	4.4	0.6	—	9.1	0.1	0.6	1.2
Construction	1.3	0.1	4.4	0.6	—	8.9	0.1	0.3	1.2
Aircraft structure	0.3	0.7	—	—	—	—	—	—	—
Ship structure	0.1	—	—	[a]	—	0.2	—	0.3	—
Electro and mechanical engineering technicians	28.3	40.1	2.0	63.3	0.1	14.6	15.5	11.9	34.1
Electronic	7.3	13.4	[a]	2.8	[a]	4.7	3.9	5.0	5.5
Electrical	2.4	3.0	—	7.4	—	2.0	2.1	1.8	0.3
Electronic-electrical	3.5	3.0	—	18.1	—	0.3	1.2	3.2	0.8
Mechanical	5.7	11.0	2.0	2.7	0.1	3.8	7.2	1.0	3.1
Electro-mechanical	9.4	9.7	—	32.3	[a]	3.8	1.1	0.9	24.4
Mathematics technicians	0.6	1.1	—	—	[a]	1.0	1.5	[a]	—
Physical science technicians	6.0	11.4	0.1	0.9	0.1	3.7	17.3	2.7	2.6
Biological, medical, dental, and related science technicians	17.1	0.8	—	0.1	99.7	0.5	58.6	25.6	6.9
Industrial engineering technicians and related specialists	4.7	8.9	—	0.9	—	1.7	0.5	5.4	1.2
Civil engineering and construction technicians and specialists	9.1	0.2	76.6	4.7	—	14.2	0.4	22.0	1.3
Technical writing and illustration			1.1	—	[a]	0.1	—	0.2	8.1
Sales and service technicians	1.3	1.4							
specialists	2.0	3.7	—	0.2	—	4.2	0.3	0.4	0.8
Safety and sanitation inspectors and related specialists	2.7	0.5	0.1	0.1	[a]	0.2	0.1	15.4	4.4
Product testing and inspection specialists	5.4	11.6	0.2	0.5	—	2.3	—	2.9	1.3
Data-processing systems analysis and programming specialists	4.1	3.4	[a]	3.3	0.1	1.5	3.7	2.0	24.2
Airway tower specialists and flight dispatchers	0.9	[a]	—	1.6	—	—	—	5.3	—
Broadcasting, motion picture, and recording studio specialists	2.0	0.3	—	16.3	—	—	0.2	0.5	2.8

[a] Less than 0.05 of a percent.
[b] Transportation, communication, and public utilities.
[c] Research, development and testing laboratories; engineering and architectural services; and business and management consulting services.

Transportation, communication, and public utilities: electro and mechanical engineering technicians; broadcasting, motion picture, and recording studio specialists.

Private medical services: biological, medical, dental, and related science technicians.

Research laboratories and architectural and engineering services: draftsmen; structural design technicians; technical writing and illustration specialists.

All other industries: sales and service technicians (mainly those manufacturing sales offices that are classified under wholesale trade); data-processing systems specialists (insurance companies, banks, brokerage houses, etc.).

AREA VARIATION IN TYPES OF TECHNICAL OCCUPATION

New York City employed 42 percent of all persons in technical occupations in 1962, far more than any other area. Relative to total area employment, however, technical occupation employment was lowest in New York City. It was highest in the Binghamton and Nassau-Suffolk areas:

Area	*Nonfarm employment*	*Technical-occupation employment*	*Percent*
New York State	6,227,656	148,684	2.4
New York City	3,495,771	62,739	1.8
Nassau-Suffolk	502,630	22,835	4.5
Westchester	232,444	5,749	2.5
Albany	232,766	7,241	3.1
Binghamton	79,031	3,886	4.9
Buffalo	425,610	12,968	3.0
Rochester	233,925	8,163	3.5
Syracuse	187,746	5,490	2.9
Utica	104,802	2,890	2.8
All other	732,931	16,723	2.3

The importance for any area of technical employment in general, or of a particular type of technical occupation, depends in large measure on the sort of industry found in the area. Tables G and H (based on table 8 in supplement A to volume 1) compare areas in respect to type of technical employment, and show, among other things, that—

Syracuse is the area whose pattern of technical employment corresponds most closely to that of the State as a whole. The Albany area also tends to conform to the Statewide pattern.

Rochester has the largest proportion of physical science technicians of all the areas. Otherwise its pattern of technical employment is similar to that of the whole State.

New York City has more biological, medical, and dental technicians than electro and mechanical engineering technicians.

Nassau-Suffolk has a relatively heavy proportion of electro and mechanical engineering technicians but is relatively light in most other categories—exceptionally so in the case of biological and medical technicians.

The Binghamton and Utica areas also have relatively large proportions of engineering technicians.

The Buffalo area is relatively light in engineering technician employment but (like Rochester) heavy in physical science technician employment.

Westchester is notable principally in its relatively high proportion of civil engineering and construction technicians and testing and inspection specialists.

GRADES OF SKILL AND RESPONSIBILITY

A limitation of the present survey is the fact that it was not possible to match levels of skill and responsibility for the various technical occupations covered. Such an analysis would have required an effort beyond the time and staff that was available.

This limitation would have been serious had an effort been made to obtain comparable data on wages and salaries paid personnel in the various technical occupations. But this was not one of the objectives of the survey.

The limitation has been partially overcome by recording for each job included in the survey whether or not, in the particular establishment in which it was found, it was a job involving supervision over other technical workers of the same kind and, for nonsupervisory jobs, whether it was a single-grade job or whether the firm had several grades.

Specifically, each occupation was assigned to a place in the following classification, which tells as nearly as possible where it stood in the company's hierarchy:

Classification of Jobs According to Grade

- Supervisory jobs
  - Supervision only, or primarily
  - Supervision plus performance of technical duties[a]
- Nonsupervisory jobs, single grade only
- Nonsupervisory jobs, multi-grade structure
  - Lowest grades
    - Lower of two grades
    - *or* Lowest third of three or more grades[b]
  - Middle grades: middle third of three or more grades[b]
  - Highest grades
    - Higher of two grades
    - *or* Highest third of three or more grades[b]

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[a] Excluded from this classification are those persons, such as group leaders and senior personnel, whose supervisory responsibilities were only incidental to their primary function.

[b] If the number of grades in a company was not exactly divisible by three, the largest number of grades was allocated to the lowest grade classification, and the next largest to the middle-grade classification. For example, if the firm had four grades of one job, the bottom two grades were put in the lowest group, the next was put in the middle group, and the remaining one in the highest group.

Grade levels assigned in the survey do not always reflect exactly the company's grade structure. For example, the survey would allocate in the following manner the six grades of a company's occupational classification that corresponded to two separate classifications being used by the survey:

Company's "Design draftsman, mechanical"	*Survey's "Draftsman, mechanical"*	*Survey's "Designer, mechanical"*
Grade 6. Senior designer	—	Highest grade
Grade 5. Designer	—	Middle grade
Grade 4. Junior designer	—	Lowest grade
Grade 3. Senior draftsman	Highest grade	—
Grade 2. Draftsman	Middle grade	—
Grade 1. Junior draftsman	Lowest grade	—

Table G. Percent Distribution of Persons in Technical Occupations According to Area, by Occupation Group

Technical occupation group	Total number, New York State	Percent distribution										
		New York State	New York City	Nassau-Suffolk	West-chester	Albany	Bing-hamton	Buffalo	Rochester	Syracuse	Utica	All other
All technical occupations	148,684	100.0	42.2	15.4	3.9	4.9	2.6	8.7	5.5	3.7	1.9	11.2
Draftsmen	20,972	100.0	49.8	11.7	3.9	3.7	2.5	9.4	4.7	3.8	1.1	9.4
Structural design technicians and related specialists	2,516	100.0	69.4	21.0	1.9	1.8	0.2	2.2	0.2	2.0	—	1.3
Construction	2,004	100.0	82.9	5.8	2.3	2.2	0.2	2.4	0.2	2.5	—	1.5
Aircraft structure	427	100.0	0.7	97.0	—	—	—	1.6	—	—	—	0.7
Ship structure	85	100.0	100.0	—	—	—	—	—	—	—	—	—
Electro and mechanical engineering technicians	42,031	100.0	33.0	24.0	3.1	4.8	4.2	7.5	5.5	4.2	2.8	10.9
Electronic	10,791	100.0	27.0	35.3	2.9	2.6	4.2	4.7	0.7	4.7	6.5	11.4
Electrical	3,618	100.0	43.9	8.2	2.2	6.4	4.5	12.0	8.0	3.5	0.1	11.2
Electronic-electrical	5,176	100.0	46.4	18.4	4.3	3.0	0.7	8.7	5.6	5.0	2.1	5.8
Mechanical	8,461	100.0	26.8	20.0	1.8	7.1	4.1	10.8	10.3	3.0	1.3	14.8
Electronic-mechanical	12,709	100.0	33.2	22.5	3.9	5.8	5.7	6.5	6.0	4.3	1.9	10.2
Electrical-mechanical	1,276	100.0	39.6	37.8	3.4	0.2	3.8	1.3	1.8	5.0	0.8	6.3
Mathematics technicians	831	100.0	18.8	56.1	1.4	9.5	0.7	5.7	1.9	3.0	—	2.9
Physical science technicians	8,969	100.0	21.5	4.4	5.1	8.5	3.0	20.0	14.9	3.6	1.0	18.0
Biological, medical, dental, and related science technicians	25,445	100.0	55.4	7.5	4.0	4.2	1.1	7.3	4.8	3.3	1.2	11.2
Industrial engineering technicians and related specialists	6,901	100.0	24.5	17.6	1.9	8.7	3.6	10.5	7.3	4.3	3.8	17.8
Civil engineering and construction technicians and specialists	13,464	100.0	41.5	10.5	6.8	5.6	2.8	10.6	4.0	3.4	1.7	13.1
Sales and service technicians	1,932	100.0	56.9	14.5	3.0	0.9	1.6	6.4	5.3	1.7	0.2	9.5
Technical writing and illustration specialists	3,034	100.0	52.2	26.3	0.7	1.8	2.1	5.0	2.3	3.6	2.6	3.4
Safety and sanitation inspectors and related specialists	4,084	100.0	57.9	4.9	1.5	4.9	1.5	7.0	3.2	2.4	2.3	14.4
Product testing and inspection specialists	8,059	100.0	20.7	27.9	7.1	5.7	1.2	10.0	6.7	4.4	1.6	14.7
Data-processing systems analysis and programming specialists	6,153	100.0	59.7	4.8	4.5	4.3	2.0	5.2	5.2	4.1	3.3	6.9
Airway tower specialists and flight dispatchers	1,373	100.0	39.0	37.6	1.8	2.5	1.4	5.4	2.3	1.3	4.0	4.7
Broadcasting, motion picture, and recording studio specialists	2,920	100.0	77.3	0.9	0.8	3.6	0.8	5.9	2.4	2.6	1.3	4.4

Table H. Percent Distribution of Persons in Technical Occupations According to Occupation Group, by Area

Technical occupation group	Percent distribution										
	New York State	New York City	Nassau-Suffolk	West-chester	Albany	Bing-hamton	Buffalo	Rochester	Syracuse	Utica	All other
All technical occupations: Number	148,684	62,739	22,835	5,749	7,241	3,886	12,968	8,163	5,490	2,890	16,723
Percent distribution											
All technical occupations: Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Draftsmen	14.1	16.6	10.8	14.2	10.7	13.6	15.2	12.0	14.4	8.2	11.8
Structural design technicians and related specialists	1.7	2.8	2.3	0.8	0.6	0.1	0.4	0.1	0.9	—	0.2
Construction	1.3	2.7	0.5	0.8	0.6	0.1	0.3	0.1	0.9	—	0.2
Aircraft structure	0.3	[a]	1.8	—	—	—	0.1	—	—	—	[a]
Ship structure	0.1	0.1	—	—	—	—	—	—	—	—	—
Electro and mechanical engineering technicians	28.3	22.0	44.2	22.9	27.8	45.3	24.4	28.4	32.1	40.5	27.4
Electronic	7.3	4.6	16.7	5.5	3.9	11.6	3.9	0.9	9.3	24.3	7.4
Electrical	2.4	2.5	1.3	1.4	3.2	4.2	3.4	3.6	2.3	0.1	2.4
Electronic-electrical	3.5	3.8	4.2	3.9	2.2	0.9	3.5	3.6	4.8	3.7	1.8
Mechanical	5.7	3.6	7.4	2.7	8.3	8.9	7.1	10.7	4.7	3.9	7.5
Electronic-mechanical	8.5	6.7	12.5	8.6	10.2	18.5	6.4	9.3	9.8	8.2	7.8
Electrical-mechanical	0.9	0.8	2.1	0.8	[a]	1.2	0.1	0.3	1.2	0.3	0.5
Mathematics technicians	0.6	0.2	2.0	0.2	1.1	0.2	0.4	0.2	0.5	—	0.1
Physical science technicians	6.0	3.1	1.7	7.9	10.5	6.9	13.8	16.2	5.9	3.0	9.6
Biological, medical, dental, and related science technicians	17.1	22.5	8.3	17.9	14.8	7.2	14.2	14.7	15.1	10.9	17.0
Industrial engineering technicians and related specialists	4.7	2.7	5.3	2.3	8.3	6.5	5.6	6.2	5.5	9.0	7.3
Civil engineering and construction technicians and specialists	9.1	8.9	6.2	16.0	10.5	9.5	11.0	6.7	8.4	7.8	10.6
Sales and service technicians	1.3	1.8	1.2	1.0	0.2	0.8	1.0	1.3	0.6	0.1	1.1
Technical writing and illustration specialists	2.0	2.5	3.5	0.3	0.8	1.6	1.2	0.9	2.0	2.7	0.6
Safety and sanitation inspectors and related specialists	2.7	3.8	0.9	1.0	2.7	1.6	2.2	1.6	1.8	3.2	3.5
Product testing and inspection specialists	5.4	2.7	9.9	9.9	6.4	2.5	6.2	6.6	6.5	4.3	7.1
Data-processing systems analysis and programming specialists	4.1	5.9	1.3	4.8	3.6	3.1	2.5	3.9	4.6	7.1	2.5
Airway tower specialists and flight dispatchers	0.9	0.9	2.3	0.4	0.5	0.5	0.6	0.4	0.3	1.9	0.4
Broadcasting, motion picture, and recording studio specialists	2.0	3.6	0.1	0.4	1.5	0.6	1.3	0.8	1.4	1.3	0.8

[a] Less than 0.05 of a percent.

The lowest of these grade levels may, of course, include different levels of responsibility and skill requirements even for the same occupation, since the lowest grade means different things in different companies. Similarly, the other grade designations may include jobs of different levels of responsibility and skill. Nevertheless, the grade distinctions used do make possible certain refinements of analysis.

About 5 percent of the 148,684 persons in technical occupations are employed in jobs that have significant supervisory responsibilities. Slightly over 51 percent are nonsupervisory workers employed where there is only a single grade; about 40 percent are in jobs that are a part of multi-grade structures; and for the remaining 4 percent the grading system was not reported:

Grade level	*Percent*
All grades	100.0
Supervisory grades	4.9
Nonsupervisory grades	95.1
Single grade only	51.0
Multi-grade	39.7
Lowest grades	16.3
Middle grades	8.0
Highest grades	15.4
Grading system not reported[a]	4.4

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[a] Jobs and workers in establishments that did not report a grading system were merged into the "single grade only" category in some of the tables in this volume and in the tables of volume 2.

In general, the larger the establishment, the more likely it is to have a multi-grade structure for technicians. (See table I below based on table 15 in supplement A to volume 1.) Single-grade systems account for the majority of technicians in establishments with up to 500 workers, but for a minority beyond that level. The fact that the proportion who are in multi-grade structures drops off in the top size group (5,000 or more workers) is explained for the most part by the fact that a few very large establishments have a single-grade system for electro and mechanical engineering technicians.

Table J (based on table 17 in supplement A to volume 1) shows the grade distribution for each of the fifteen technician occupation groups. The differences among the fifteen is influenced to some extent by differences in the size of the establishments in which a particular occupation is carried on. Another factor, whose importance could not readily be measured, is the job-classification practice prevalent in the industry or industries with which a particular occupation is mainly associated; government agencies, for example, usually have a multi-grade structure.

Reinforcing the picture that a large establishment is especially likely to have a multi-grade system for nonsupervisory technical occupations is the fact that the average multi-grade establishment has a total employment of about 1,700 (workers of all sorts), compared with about 300 in the case of single-grade systems. A similar contrast exists in each of the fifteen major technical occupation groups except the three smallest.[1]

Over-all, establishments with technical occupations average a total employment of about 800. Among the fifteen occupation groups, the average (median) ranges from 100 workers of all sorts for establishments employing sales and service technicians to 6,000 for those with mathematics technicians. (See table 16 in supplement A to volume 1 for details.)

SUPERVISORS AND SUPERVISION

The preceding section of this chapter pointed out that roughly 5 percent of the personnel in technical occupations have significant responsibility for supervising other technical personnel. No data were given, however, on the extent to which technical personnel have supervisory responsibility over nontechnical personnel, such as mechanics and other craftsmen, produc-

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[1] The small number of technicians in these occupation groups is the only characteristic that is common to the three: mathematics; sales and service; and airway tower specialists and flight dispatchers.

Table I. Percent Distribution of Persons in Technical Occupations According to Grade, by Size of Establishment

Size of establishment (number of employees)	Number in all grades	Percent distribution						
		All grades	Supervisory grades	Nonsupervisory grades				Grading system not reported
				Single grade only	Multi-grade			
					Lowest grades	Middle grades	Highest grades	
All sizes	148,684	100.0	4.9	51.0	16.3	8.0	15.4	4.4
1- 3	5,798	100.0	0.7	98.1	0.8	[a]	0.4	—
4- 19	10,078	100.0	3.3	88.8	3.6	0.7	3.5	0.1
20- 49	9,706	100.0	4.8	73.4	8.6	3.1	9.7	0.4
50- 99	11,937	100.0	4.6	64.1	13.5	5.2	12.6	—
100- 199	11,447	100.0	5.6	66.6	10.8	4.2	12.6	0.2
200- 499	15,430	100.0	5.5	59.4	14.7	4.9	15.1	0.4
500- 999	15,936	100.0	6.2	43.1	19.8	8.9	20.1	1.9
1,000-1,999	16,096	100.0	6.1	32.5	24.7	11.6	21.0	4.1
2,000-4,999	18,801	100.0	5.2	30.9	21.7	10.8	18.9	12.5
5,000 or more	33,455	100.0	4.4	35.1	19.9	12.9	18.4	9.3

[a] Less than 0.05 of a percent.

Table J. Percent Distribution of Persons in Technical Occupations According to Grade, by Occupation Group

Technical occupation group	Number in all grades	Percent distribution						
		All grades	Supervisory grades	Nonsupervisory grades				Grading system not reported
				Single grade only	Multi-grade			
					Lowest grades	Middle grades	Highest grades	
All technical occupations	148,684	100.0	4.9	51.0	16.3	8.0	15.4	4.4
Draftsmen	20,972	100.0	2.6	50.3	15.2	10.7	19.8	1.4
Structural design technicians and related specialists	2,516	100.0	5.6	36.6	16.2	9.0	32.6	—
Electro and mechanical engineering technicians	42,031	100.0	5.0	47.8	14.7	7.6	16.6	8.3
Mathematics technicians	831	100.0	5.5	55.4	15.5	10.2	6.9	6.5
Physical science technicians	8,969	100.0	2.6	35.3	24.9	16.5	15.3	5.4
Biological, medical, dental, and related science technicians	25,445	100.0	4.1	66.8	12.6	4.8	9.7	2.0
Industrial engineering technicians and related specialists	6,901	100.0	8.5	43.8	10.5	10.2	15.6	11.4
Civil engineering and construction technicians and specialists	13,464	100.0	3.7	59.0	16.4	7.9	13.0	—
Sales and service technicians	1,932	100.0	2.4	87.7	5.7	0.2	4.0	—
Technical writing and illustration specialists	3,034	100.0	8.4	44.4	17.7	7.0	16.1	6.4
Safety and sanitation inspectors and related specialists	4,084	100.0	6.8	28.3	42.8	4.2	17.8	0.1
Product testing and inspection specialists	8,059	100.0	4.5	46.2	19.7	7.6	15.3	6.7
Data-processing systems analysis and programming specialists	6,153	100.0	10.5	43.8	18.6	7.2	16.9	3.0
Airway tower specialists and flight dispatchers	1,373	100.0	13.8	9.6	23.0	16.0	37.6	—
Broadcasting, motion picture, and recording studio specialists	2,920	100.0	11.5	69.0	16.0	0.2	3.3	—

tion or clerical workers or incidental supervisory responsibility over lower-grade technical personnel. Nor was any information given concerning the extent to which persons in technical occupations are supervised by engineers and scientists or by people in managerial and other occupations.

This section fills these gaps to some degree.

Extent of Supervision

As to the question of how widely personnel in technical occupations have supervisory functions or responsibilities: Reports of employers indicate that approximately 18 percent of the total number have some supervisory responsibilities. This includes supervision over other persons in technical occupations and also supervision over persons in nontechnical occupations. It appears, then, that of all persons in technical occupations:

- 18 percent have some supervisory responsibilities
  - 5 percent have significant supervisory responsibility over persons in technical occupations (some of them also supervise persons in other occupations)
  - 13 percent have supervisory responsibility over persons in other than technical occupations or have incidental supervisory responsibility over persons in technical occupations.

The following occupations have the highest proportions of workers with supervisory responsibilities (table 18 in supplement A to volume 1 gives detail):

Civil engineering and construction technicians and specialists	41.4%
Structural design technicians and related specialists	39.9
Data-processing systems analysis and programming specialists	25.3
Electro and mechanical engineering design technicians	23.0
Technical writing and illustration specialists	19.1

Supervisors' Occupation

Probably the majority of persons in technical occupations are supervised by professional engineers and scientists—at least indirectly. Employers' reports indicate that 42 percent are supervised directly by engineers and scientists (including mathematicians and architects), while 34 percent are supervised by technicians or technical specialists of higher grade. The remaining 24 percent are supervised by persons in other occupations, mainly establishment or department managers or administrators or production or sales supervisors—persons who do not function primarily, if at all, as engineers or scientists.

Table K. Distribution of Persons in Technical Occupations According to Occupation of Their Supervisors, by Technical Occupation Group

Technical occupation group	Occupation of supervisor			
	Total	Engineer or scientist	Higher-level technical worker	Other
A. Number				
All technical occupations	148,684	62,676	50,899	35,109
Draftsmen	20,972	12,830	6,009	2,133
Structural design technicians	2,516	1,174	1,068	274
Electro and mechanical engineering technicians	42,031	19,895	14,136	8,000
Field:				
Electronic	10,791	5,282	4,244	1,265
Electrical	8,794	4,517	2,369	1,908
Mechanical	8,461	5,445	1,655	1,361
Electro-mechanical	13,985	4,651	5,868	3,466
Function:				
Design	7,689	5,742	1,134	813
Development	11,936	7,636	3,199	1,101
Troubleshooting and related	22,406	6,517	9,803	6,086
Mathematics technicians	831	671	148	12
Physical science technicians	8,969	6,759	1,368	842
Biological, medical, dental, and related science technicians	25,445	6,598	9,662	9,185
Industrial engineering technicians	6,901	3,273	1,828	1,800
Civil engineering and construction technicians	13,464	6,899	3,358	3,207
Sales and service technicians	1,932	244	179	1,509
Technical writing and illustration specialists	3,034	829	1,263	942
Safety and sanitation inspectors	4,084	336	2,253	1,495
Product testing and inspection specialists	8,059	1,970	3,884	2,205
Data-processing systems analysis and programming specialists	6,153	909	2,501	2,743
Airway tower specialists and flight dispatchers	1,373	—	1,290	83
Broadcasting, motion picture, and recording studio specialists	2,920	289	1,952	679
B. Percent distribution				
All technical occupations	100.0	42.2	34.2	23.6
Draftsmen	100.0	61.1	28.7	10.2
Structural design technicians	100.0	46.7	42.4	10.9
Electro and mechanical engineering technicians	100.0	47.4	33.6	19.0
Field:				
Electronic	100.0	49.0	39.3	11.7
Electrical	100.0	51.4	26.9	21.7
Mechanical	100.0	64.3	19.6	16.1
Electro-mechanical	100.0	33.3	41.9	24.8
Function:				
Design	100.0	74.7	14.7	10.6
Development	100.0	64.0	26.8	9.2
Troubleshooting and related	100.0	29.1	43.7	27.2
Mathematics technicians	100.0	80.8	17.8	1.4
Physical science technicians	100.0	75.3	15.3	9.4
Biological, medical, dental, and related science technicians	100.0	25.9	38.0	36.1
Industrial engineering technicians	100.0	47.4	26.5	26.1
Civil engineering and construction technicians	100.0	51.3	24.9	23.8
Sales and service technicians	100.0	12.6	9.3	78.1
Technical writing and illustration specialists	100.0	27.3	41.7	31.0
Safety and sanitation inspectors	100.0	8.2	55.2	36.6
Product testing and inspection specialists	100.0	24.4	48.2	27.4
Data-processing systems analysis and programming specialists	100.0	14.8	40.6	44.6
Airway tower specialists and flight dispatchers	100.0	—	94.0	6.0
Broadcasting, motion picture, and recording studio specialists	100.0	9.9	66.8	23.3

Table L. Proportion in Technical Occupations Who Are Women

(Also percent distribution of women by technical occupation)

Technical occupation group	All persons in technical occupations	Women in technical occupations		
		Total number	As percent of total employment	Distribution by occupation
All technical occupations	148,684	18,335	12.3	100.0
Draftsmen	20,972	519	2.5	2.8
Structural design technicians and related specialists	2,516	22	0.9	0.1
Electro and mechanical engineering technicians	42,031	433	1.0	2.4
Mathematics technicians	831	357	43.0	1.9
Physical science technicians	8,969	952	10.6	5.2
Chemical and related	5,162	609	11.8	3.3
All other	3,807	343	9.0	1.9
Biological, medical, dental, and related science technicians	25,445	14,584	57.3	79.5
Agricultural and related	340	47	13.8	0.3
Biological and medical laboratory	9,898	5,773	58.3	31.4
General medical assistants, doctor's office (other than nurse or secretary)	1,114	1,077	96.7	5.9
X-ray and related equipment technicians	3,013	1,284	42.6	7.0
Other medical technicians	1,801	1,055	58.6	5.8
Therapists	1,883	1,083	57.5	5.9
Medical record librarians	347	313	90.2	1.7
Dental laboratory technicians	2,844	125	4.4	0.7
Dental hygienists	1,874	1,759	93.9	9.6
Dental assistants	2,331	2,068	88.7	11.2
Industrial engineering technicians and related specialists	6,901	66	1.0	0.4
Civil engineering and construction technicians and specialists	13,464	10	0.1	0.1
Sales and service technicians	1,932	10	0.5	0.1
Technical writing and illustration specialists	3,034	217	7.2	1.2
Safety and sanitation inspectors and related specialists	4,084	52	1.3	0.3
Product testing and inspection specialists	8,059	595	7.4	3.2
Instruments, meters, and related equipment	2,335	162	6.9	0.9
Machinery, transportation, and other metal equipment, and appliances n.e.c.	2,762	98	3.5	0.5
Chemical and other nonmetal products n.e.c.	1,926	216	11.2	1.2
Food and agricultural products	563	110	19.5	0.6
Industrial X-ray and related processes	308	4	1.3	[a]
General and other	165	5	3.0	[a]
Data-processing systems analysis and programming specialists	6,153	515	8.4	2.8
Systems analysts	1,875	75	4.0	0.4
Programmers	3,205	388	12.1	2.1
Combination: systems analysis and programming	936	48	5.1	0.3
Project planners	137	4	2.9	[a]
Airway tower specialists and flight dispatchers	1,373	2	0.1	[a]
Broadcasting, motion picture, and recording studio specialists	2,920	1	[a]	[a]

[a] Less than 0.05 of a percent.

Mathematics technicians, a relatively small group, have the highest degree of technical supervision—81 percent are supervised by engineers or scientists and 18 percent by higher-level technicians. About 75 percent of the technicians in the fields of physical science and of electro and mechanical engineering design are supervised by engineers or scientists.

Occupations in which supervisors are predominantly persons in higher-level technical occupations are: airway tower specialists and flight dispatchers (94 percent); broadcasting, motion picture, and recording studio specialists (67 percent); and safety and sanitation inspectors (55 percent).

Table K gives the figures by occupation group and shows that in only one of the groups—sales and service technicians—are less than half of the workers (22 percent) supervised by engineers, scientists, or higher-grade technicians.

EMPLOYMENT OF WOMEN

Women constituted one-eighth of all employees in technical occupations in 1962. This is decidedly below the ratio for all occupations combined, estimated to be about one-third in New York State.

Among technical occupations, the proportion of women is especially low in the case of draftsmen and of electro and mechanical engineering, industrial engineering, and civil and construction engineering technicians. Relatively large proportions, on the other hand, of the mathematics technicians and of the biological, medical, dental, and related technicians and specialists are women. Other occupations in which the ratio of women to total employment is substantial though not large are physical science technicians (especially in chemical laboratories), technical writing and illustration specialists, product testing and inspection specialists, and data-processing programmers.

Table L (based on table 19 in supplement A to volume 1) gives data for 33 occupation groups and subgroups, and shows that, as a field of employment, the biological-medical-dental field overshadows all others: 80 percent of all women employed in technical occupations were in this group in 1962.

The prominence of the biological-medical-dental group is reflected in the fact that, in a breakdown by industry, private medical services account for half the 18,335 women in technical occupations. Government is second. (The following percent distribution is based on table 20 in supplement A to volume 1, which also shows occupational data.)

All industries	100.0%
Private medical services	53.2
Government	16.5
Manufacturing	13.4
Private colleges and schools	7.9
Research laboratories and engineering services	2.7
Transportation, communication, and public utilities	1.1
Construction	negligible
All other	5.2

In establishments that do not employ women in a technical occupation, employers were asked whether the absence of women was due to a lack of qualified applicants or to hiring policies. About 70 percent of all persons in technical occupations work in the establishments with no women in such jobs, and half of these work for employers who stated that they would

Table M. Willingness of Establishments with No Women to Hire Women, by Occupation Group

(Workers in each technical occupation group who are employed in establishments with no women in that occupation, as percent of all workers in the occupation; and proportion of those workers who are in establishments where the employer is willing to hire women)

Technical occupation group	Number occupation in group	Percent who are in establishments having no women in given group		
		In all such establishments	In those willing to hire women	In those reluctant to hire women
All technical occupations	148,684	71.1	37.2	33.9
Draftsmen	20,972	74.9	52.9	22.0
Structural design technicians and related specialists	2,516	86.2	65.0	21.2
Electro and mechanical engineering technicians	42,031	88.5	35.3	53.2
Mathematics technicians	831	38.4	23.1	15.3
Physical science technicians	8,969	60.5	35.6	24.9
Biological, medical, dental, and related science technicians	25,445	16.4	14.0	2.4
Industrial engineering technicians and related specialists	6,901	94.7	50.8	43.9
Civil engineering and construction technicians and specialists	13,464	89.2	26.5	62.7
Sales and service technicians	1,932	98.0	41.3	56.7
Technical writing and illustration specialists	3,034	72.5	67.3	5.2
Safety and sanitation inspectors and related specialists	4,084	85.4	32.8	52.6
Product testing and inspection specialists	8,059	76.7	40.0	36.7
Data-processing systems analysis and programming specialists	6,153	67.6	55.3	12.3
Airway tower specialists and flight dispatchers	1,373	98.8	82.8	16.0
Broadcasting, motion picture, and recording studio specialists	2,920	99.7	62.9	36.8

not hire, or would be reluctant to hire, women in the specific occupation or occupations in question.

The fact that there are no women working in a certain occupation in a certain establishment does not necessarily mean that the employer concerned is especially reluctant to employ women. The data by occupation group in table M indicate that the proportion of establishments without women in a particular occupation is not a definite indicator of the employers' reluctance to hire them. For example, establishments employing only male draftsmen and technical writing and illustration specialists account for about 75 percent of the workers in each of these occupational categories. A reluctance to hire women in these jobs was expressed by the employers of 22 percent of the draftsmen but by the employers of only 5 percent of the writers and illustrators.

UNIONIZATION

Approximately 17 percent of all workers in technical occupations were specifically covered at the time of the survey by an agreement between a union and an employer, according to reports of employers. This percentage is smaller than the estimated percent for all workers in the State, which is around 30.

It will be seen from table N (based on table 21 in supplement A to volume 1) that broadcasting and related studio specialists, with 77 percent covered by union agreements, were most fully unionized, followed by product testing and inspection specialists with 42 percent and electro and mechanical engineering technicians with 33 percent. The relatively large proportion of mathematics technicians under union agreements (24 percent) is explained by a concentration of these employees in a few large, highly unionized electronic and aerospace firms.

Over half of those covered by union agreements are electro and mechanical engineering technicians, among whom troubleshooters and related technicians are the vast majority. Other groups accounting for a substantial proportion of all workers in technical occupations under union agreements were product testing and inspection specialists, draftsmen, and broadcasting and related studio specialists.

Table N. Workers Covered by Union Agreements As Percent of All Persons In Technical Occupations, by Occupation Group

(Also percent distribution, by occupation group, of those covered and not covered)

Technical occupation group	Percent distribution according to occupational group			Those under agreements as percent of total
	Total	Under agreement	Not under agreement	
All technical occupations: Number	148,684	25,799	122,885	17.4
Percent distribution				
All technical occupations: Percent	100.0	100.0	100.0	—
Draftsmen	14.1	9.2	15.1	11.3
Structural design technicians and related specialists	1.7	0.3	2.0	3.3
Electro and mechanical engineering technicians	28.3	53.1	23.2	32.6
Field:				
Electronic	7.3	11.7	6.3	28.0
Electrical	5.9	14.3	4.2	42.0
Mechanical	5.7	6.3	5.6	19.1
Electronic-mechanical	9.4	20.8	7.1	38.3
Function:				
Design	5.1	4.0	5.4	13.5
Development	8.0	9.9	7.7	21.4
Troubleshooting and related	15.2	39.2	10.1	45.0
Mathematics technicians	0.6	0.8	0.5	23.5
Physical science technicians	6.0	3.6	6.5	10.3
Biological, medical, dental, and related science technicians	17.1	3.0	20.1	3.0
Industrial engineering technicians and related specialists	4.7	1.9	5.2	7.2
Civil engineering and construction technicians and specialists	9.1	4.9	9.9	9.5
Sales and service technicians	1.3	0.1	1.5	1.4
Technical writing and illustration specialists	2.0	0.4	2.4	3.7
Safety and sanitation inspectors and related specialists	2.7	[a]	3.3	0.2
Product testing and inspection specialists	5.4	13.0	3.8	41.5
Data-processing systems analysis and programming specialists	4.1	0.2	5.0	0.8
Airway tower specialists and flight dispatchers	0.9	0.8	0.9	15.1
Broadcasting, motion picture, and recording studio specialists	2.0	8.7	0.6	76.6

[a] Less than 0.05 of a percent.

On an industry basis, by far the highest proportion of union coverage of technical occupations was in the transportation, communication, and public utility group, especially in the communication industries and in air and railroad transportation. Manufacturing is the only other broad industry division with unionization above the average. (See table 23 in supplement A to volume 1.) The areas of the State where such unionization is above the average are Nassau-Suffolk, Utica, Buffalo, and Syracuse, as is seen in the following table, based on table 22 in supplement A to volume 1:

Area	*Persons in technical occupations*		
	Total number	*Under union agreements*	
		Number	*Percent*
New York State	148,684	25,799	17.4
New York City	62,739	10.896	17.4
Nassau-Suffolk	22,835	6,068	26.6
Westchester	5,749	966	16.8
Albany	7,241	653	9.0
Binghamton	3,886	90	2.3
Buffalo	12,968	2,907	22.4
Rochester	8,163	918	11.2
Syracuse	5,490	1,046	19.1
Utica	2,890	718	24.8
All other	16,723	1,537	9.2

Both unions affiliated with the AFL-CIO and unions not affiliated with it represent workers in technical occupations. A number of the largest employers of technical workers in New York State have agreements with independent, one-company unions that include these workers.

The following unions account for the large majority of the workers in technical occupations who are covered by national and international unions:

Automobile, Aerospace and Agricultural Implement Workers of America, International Union, United (AFL-CIO)
Broadcast Employees and Technicians, National Association of (AFL-CIO)
Building Service Employees' International Union (AFL-CIO) (represents hospital workers in the New York Metropolitan area)
Chemical Workers Union, International (AFL-CIO)
Communications Association, American (Independent)
Communications Workers of America (AFL-CIO)
District 50, United Mine Workers (Independent)
Electrical, Radio, and Machine Workers, International Union of (AFL-CIO)
Electrical, Radio, and Machine Workers of America, United (Independent)
Electrical Workers, International Brotherhood of (AFL-CIO)
Engineers, American Federation of Technical (AFL-CIO)
Ironworkers, International Association of Bridge, Structural, and Ornamental (AFL-CIO)
Machinists, International Association of (AFL-CIO)
Office Employees International Union (AFL-CIO)
Oil, Chemical, and Atomic Workers International Union (AFL-CIO)
Retail, Wholesale and Department Store Union (AFL-CIO) (represents hospital workers in the New York Metropolitan area)
Steelworkers of America, United (AFL-CIO)
Telegraphers' Union, Commercial (AFL-CIO)
Telephone Unions, Alliance of Independent (Independent)
Transport Workers Union of America (AFL-CIO)
Utility Workers Union of America (AFL-CIO)

ENGINEERING TECHNICIANS: WHO ARE THEY?

A good bit of discussion has taken place in technical-education literature on the question of just who the "engineering technician" is and how he is distinguished from other kinds of technicians and persons engaged in technical occupations. Probably the best known definition is that of the American Society for Engineering Education, which defines "Engineering Technology" as—

> that part of the engineering field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational area between the craftsman and the engineer at the end of the area closest to the engineer.[1]

Useful as it is, this definition does not provide a clear identification of engineering technicians. One difficulty arises because of uncertainty concerning the meaning of the term "technical skills." Jobs supporting engineering activities do not always involve use of technical skills if by this is meant the manipulative and artisan skills of the craftsman. Assistance given to an engineer in working out design and mathematical problems, for example, may not. The establishment of reliability and quality-control standards, technical writing, and the preparation of product and equipment specifications are examples of other activities in which there may be an application of engineering or scientific knowledge but little use of technical skills in this sense.

Parallel questions arise if the above definition is adapted to defining a science technician. He uses scientific knowledge to assist and support the scientist(chemist, physicist, metallurgist, etc.) in laboratory research or other activities. But the technical skills he applies may be limited.

We have a basis for identifying such jobs if we take engineering technicians or science technicians to be persons of less than full professional rank who assist or support engineers or scientists by performing one or more engineering or scientific functions, whether or not they use technical skills.

To cover the entire field of technical occupations, we need, in addition to technicians, the category of "technical specialist." Technical-specialist occupations do not involve the performance of engineering or scientific functions to any substantial degree. They do include the application of technical or scientific knowledge, but the application tends to be narrow in scope, repetitive, and often—though not always—one that can be learned without protracted education or training. Some technical-specialist jobs require orientation or special competence in subjects unrelated to science and engineering as such (writing and illustrating, for example).

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[1] American Society for Engineering Education, *Characteristics of Excellence in Engineering Technology Education* (1962), p. 11.

Generally speaking, the work of an engineering or science technician is performed—when no technician is available—by the engineer or scientist himself. Technical-specialist jobs, on the other hand, are not often performed by engineers or scientists. Typically they are filled by persons trained to do the particular job.[1]

A rough classification of persons employed in technical occupations in New York State in 1962 indicates that two-thirds were in the technician category and one-third in the specialist category:

	Number	*Percent*
Primary engineering technicians	30,426	20.5
Secondary engineering technicians	46,735	31.4
Science technicians	21,090	14.2
All technicians	98,251	66.1
All technical specialists	50,433	33.9
All technical occupations	148,684	100.0

A primary engineering technician assists an engineer in one of his primary or principal functions (e.g., design and development), while a secondary engineering technician assists him by doing work that engineers perform relatively infrequently (e.g., drafting, and troubleshooting of production equipment).

Table O classifies technical occupations under the four headings used in the small table just above. In some cases an occupation is on the border line; though classified under one heading, it perhaps could just as well have appeared under a different heading. Grade differences that occur within individual occupations could not adequately be taken into account in the classifications.

The distinctions drawn among the engineering technician groups and between them and the technical specialists are not intended to imply the absence of relationships in job content. (1) There is overlapping between some secondary and primary engineering technicians. For example, high-level draftsmen may overlap low-level engineering design technicians. (2) Some groups shade into others, so that in the classification process one finds many borderline cases that could go either way. For example, product testing and inspection specialist work shades into some troubleshooting engineering technician and science laboratory testing work. (3) Functions separately classified here are found combined in the same job with some frequency (here classified according to which one appeared to occupy the major part of the person's time). For example, development engineering technician work and production planning and parts estimating may be combined in the same job in some establishments.

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[1] The term "industrial technician" has been applied by some to technicians other than engineering technicians. This term has not been found in this study to be a particularly helpful or suitable way of characterizing the technical specialist. For a discussion of the term, see Carl J. Schaefer and Robert E. McCord, "Needed: A Definition of the Technician," *Technical Education News*, June 1963, pages 23-24.

Table O. Technical Occupations Grouped As Primary and Secondary Engineering Technicians, Science Technicians, and Technical Specialists

(Number of technicians and specialists)

Kind of technical occupation	Number	Kind of technical occupation	Number
Primary engineering technicians		*Technical specialists*	
Structural design technicians (excluding loftsmen)	2,293	Medical equipment and related technicians	4,814
Electro and mechanical engineering technicians: design and development	19,625	General medical assistants, doctor's office	1,114
Mathematics technicians	831	Medical record librarians	347
Quality control and reliability technicians	1,279	Dental hygienists	1,874
Industrial engineering technicians, general	295	Dental assistants	2,331
Surveyors (excluding instrumentmen)	1,171	Dental laboratory technicians	2,844
Civil engineering and construction technicians	4,932	Production planners, estimators, and related specialists	2,918
Secondary engineering technicians		Equipment specialists	480
Draftsmen	20,972	Construction inspectors	2,804
Loftsmen	223	Construction specifications writers and cost estimators	3,347
Electro and mechanical engineering technicians: installation and troubleshooting	22,406	Sales and service technicians	1,932
Time and motion study men and standard setters	1,104	Technical writing and illustration specialists	3,034
Industrial process methods men	825	Safety and sanitation inspectors and related specialists	4,084
Broadcasting and studio equipment and maintenance technicians	1,205	Product testing and inspection specialists	8,059
Science technicians		Data-processing systems analysis and programming specialists	6,153
Physical science technicians	8,969	Airway tower specialists and flight dispatchers	1,373
Biological and medical laboratory technicians (including agriculture)	10,238	Instrumentmen (surveying)	1,210
Therapists	1,883	Broadcasting and related studio specialists	1,715

Some of the technical occupations whose job content is in part related are listed here, grouped under the element they have in common:

Drafting
- Draftsmen
- Structural design technicians
- Electro and mechanical design technicians
- Electro and mechanical development technicians
- Loftsmen
- Surveyors
- Civil engineering technicians

Laboratory analysis
- Physical science technicians
- Biological and medical laboratory technicians
- Product testing and inspection
- Electro and mechanical development technicians

Manufacturing and parts planning, estimating, scheduling, expediting
- Draftsmen
- Production planners, estimators, coordinators, and related specialists
- Industrial process methods men
- Equipment specialists
- Electro and mechanical design and development technicians
- Structural design technicians and related specialists

Mathematical analysis
- Mathematics technicians
- Structural design technicians
- Electro and mechanical design technicians
- Electro and mechanical development technicians
- Electro and mechanical troubleshooting technicians
- Draftsmen
- Quality control and reliability technicians
- Data-processing programmers

Technical writing and illustrating
- Technical writing and illustration specialists
- Sales and service technicians
- Electro and mechanical development technicians
- Construction specification writers

Testing and inspection
- Product testing and inspection specialists
- Electro and mechanical troubleshooting technicians
- Electro and mechanical development technicians
- Physical science technicians
- Industrial safety and sanitation inspectors
- Quality control and reliability technicians
- Civil engineering and construction technicians
- Construction inspectors

Troubleshooting, maintenance, and repair
- Electro and mechanical troubleshooting technicians
- Electro and mechanical development technicians
- Sales and service technicians
- Equipment specialists
- Quality control and reliability technicians
- Broadcasting maintenance technicians

III. VACANCIES

Employers were asked to report the number of persons they were actively seeking to employ in technical occupations at the time of the survey. Over-all, 4,562 such vacancies were reported, a number equal to 3 percent of all persons employed in technical occupations.[1]

This number probably does not reflect all employment opportunities for highly-qualified people. Vacancies were reported only if the establishment was *actively seeking* qualified technical personnel at the time of the survey. Some establishments, willing to employ such people in specific occupations, were not actively seeking them because of a belief that they were not available. Others indicated that, though they had no identifiable positions open at the time, they were on the lookout for specialized personnel.

Recognizing that vacancy rates in occupations with relatively small numbers may be fairly wide of the mark, certain technical occupations stand out in terms both of volume of vacancies and of vacancy rates. Electro and mechanical engineering technicians account for 31 percent of all vacancies; within this category, vacancies in the electronics and electro-mechanical fields bulk especially large—they have vacancy rates of between 4 and 5 percent. Biological, medical, dental, and related technicians account for nearly 23 percent of all vacancies; biological and medical laboratory technicians stand out, and so do therapists. Draftsmen and civil engineering and construction technicians and specialists also account for substantial proportions of total vacancies. (Table P, based on table 24 in supplement A to volume 1.)

Table P. Percent Distribution of Vacancies Among Technical Occupation Groups and Selected Subgroups, and Corresponding Vacancy Rates

Technical occupation group	Percent[a]	Rate[b]
All technical occupations	100.0	3.1
Electro and mechanical engineering technicians	31.0	3.4
Field: Electro-mechanical	(12.2)	(4.0)
Field: Electronic	(11.1)	(4.7)
Function: Troubleshooting and related	(19.4)	(3.9)
Biological, medical, dental, and related science technicians	22.7	4.1
Biological and medical laboratory	(8.3)	(3.9)
Therapists	(5.7)	(14.0)
Draftsmen	14.7	3.2
Architectural and structural	(5.0)	(3.6)
Civil engineering and construction technicians and specialists	12.6	4.3
Data-processing systems analysis and programming specialists	4.2	3.1
Safety and sanitation inspectors and related specialists	3.4	3.8
Technical writing and illustration specialists	2.6	3.9
Product testing and inspection specialists	2.5	1.4
Physical science technicians	2.4	1.2
Industrial engineering technicians and related specialists	2.1	1.4
Structural design technicians and related specialists	1.0	1.8
Sales and service technicians	0.6	1.4
Broadcasting, motion picture, and recording studio specialists	0.2	0.3
Mathematics technicians	[c]	0.2
Airway tower specialists and flight dispatchers	—	0.0

[a] All vacancies (100.0 percent) numbered 4,562.
[b] Vacancies as percent of employment in occupation group.
[c] Less than 0.05 of a percent.

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[1] The vacancy ratio of this chapter is the number of vacancies divided by the number of persons employed. The ratio would show up slightly smaller if the denominator were "desired employment," that is, included both vacancies and employment.

Government agencies have the highest technical occupation vacancy rate of all employers:

Industry	*Rate*
All industries	3.1
Government	5.5
Research laboratories and engineering services	3.6
Private medical services	3.6
Manufacturing	2.4
Construction	2.1
Transportation, communication, and public utilities	1.5
Private colleges and schools	0.4
All other	4.3

When the technical occupation groups are examined separately, it appears that the government vacancy rate is the highest, or among the highest, in most but not all of the groups. (See table 25 in supplement A to volume 1.) To some extent these higher rates may reflect more nearly complete reporting by government agencies than by private industry; but complaints of officials in a number of government agencies that they have been unable to recruit adequate numbers of qualified persons in technical occupations suggest that government generally has experienced unusual difficulty in filling vacancies.

The average vacancy rate of employers in New York City is only 2.9 percent, less than that for the State as a whole, so its share of the vacancy total is only 40 percent, as the following percent distribution shows:

Area	*Percent*	*Rate*
New York State	100.0	3.1
New York City	40.4	2.9
Nassau-Suffolk	19.3	3.9
Buffalo	7.2	2.5
Albany	4.6	2.9
Rochester	4.2	2.3
Binghamton	3.6	4.2
Westchester	3.5	2.8
Syracuse	2.8	2.3
Utica	1.9	3.0
All other	12.5	3.4

The highest vacancy rates are found in the Binghamton area (4.2) and in Nassau-Suffolk (3.9).[1] As table 26 in supplement A to volume 1 shows, the occupations in shortest supply in Binghamton are technical writers and illustrators (34 vacancies per 100 jobs), civil engineering and construction technicians (17), and construction cost estimators (9). In Nassau-Suffolk they are therapists (21), civil engineering and construction technicians and dental assistants (14), and electronic and chemical technicians (10).

In New York City the highest rate is found among therapists (15 vacancies per 100 jobs), safety inspectors (7), construction inspectors (7), dental technicians (5), and data-processing programmers (5).

Single-grade occupations account for almost two-thirds of all vacancies, and have a rate of 3.9 vacancies per 100 employed. In occupations with two or more grades, the vacancy rate in the lowest grades (3.5) is almost twice that in the highest grades (1.9). Only one vacancy was reported for every 100 persons employed in supervisory grades.

In the entrance grades the largest relative demand —7.3 vacancies per 100 employed—is for data-processing systems analysis and programming specialists. Other occupations having high vacancy rates in the lowest grades are civil engineering and construction technicians and specialists (6.4), biological, medical, dental, and related science technicians (5.9), and safety and sanitation inspectors and related specialists (5.0). In the case of single-grade occupations, the workers in shortest supply are electronic technicians (10.4) and technical writing and illustration specialists (6.8). Table Q (based on table 27 in supplement A to volume 1) shows vacancy rates in the various grades for each technical occupation group.

Active vacancies were reported by about 9 percent of the 14,595 establishments that employ persons in technical occupations. These 1,277 establishments employ, on the average, 39 such workers, compared with an average of 7 in establishments that did not report vacancies.

The over-all technical occupation vacancy rate is 3 percent, in relation to all persons in technical occupations. When vacancies are related to the workers only in those establishments that reported one or more vacancies, the rate becomes three times as great, 9 percent. And then counting only the workers in those occupations for which these establishments reported vacancies, the vacancy rate rises to 19 percent.

Half of the 1,277 establishments with vacancies reported only one vacancy; this group of establishments averages 10 persons in technical occupations (19 of 1,277 employed no one in a technical occupation at the time of the survey). At the other extreme there were 6 percent that reported 10 or more vacancies; they averaged about 280 persons in technical occupations per establishment, and had 42 percent of all the vacancies reported. For this small group the vacancy rate (9) is approximately the same as that for all establishments with vacancies but slightly less than that for establishments reporting only one vacancy (9.7).

About 76 percent of the workers employed in technical occupations in establishments with vacancies are in establishments with a rate of less than 10 percent. An additional 14 percent are in establishments with rates of between 10 and 20 percent. (Table R.)

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[1] It is likely that because of the cutback in defense-goods production on Long Island that the Nassau-Suffolk vacancy rate is now lower than the 1962 rate of 3.9.

Table Q. Vacancy Rates in Technical Occupation Groups, by Grade

Technical occupation group	All grades	Supervisory grades	Nonsupervisory grades: Single grade only	Multi-grade[a]: Lowest grades	Multi-grade[a]: Middle grades	Multi-grade[a]: Highest grades
All technical occupations	3.1	0.9	3.9	3.5	2.0	1.9
Draftsmen	3.2	0.9	4.3	2.8	1.9	1.8
Structural design technicians and related specialists	1.8	0.0	2.5	3.7	1.8	0.5
Electro and mechanical engineering technicians	3.4	0.2	5.8	2.5	0.6	1.1
Mathematics technicians	0.2	0.0	0.0	1.6	0.0	0.0
Physical science technicians	1.2	1.7	1.2	1.3	1.4	1.4
Biological, medical, dental, and related science technicians	4.1	2.3	4.2	5.9	2.6	3.4
Industrial engineering technicians and related specialists	1.4	1.0	1.6	1.9	2.3	0.8
Civil engineering and construction technicians and specialists	4.3	0.2	3.6	6.4	5.5	4.8
	1.4	0.0	1.6	0.0	0.0	0.0
Sales and service technicians						
Technical writing and illustration specialists	3.9	0.4	6.8	1.9	2.8	1.6
Safety and sanitation inspectors and related specialists	3.8	4.0	2.0	5.0	4.7	3.3
Product testing and inspection specialists	1.4	0.3	2.1	1.5	0.7	0.6
Data-processing systems analysis and programming specialists	3.1	0.8	1.6	7.3	6.3	3.1
Airway tower specialists and flight dispatchers	0.0	0.0	0.0	0.0	0.0	0.0
Broadcasting, motion picture, and recording studio specialists	0.3	1.2	[b]	0.4	0.0	3.2

[a] No vacancies were reported in occupations in which the grading system was not obtained.
[b] Less than 0.05 of a percent.

Table R. Establishments with Technical Occupations and Workers in Those Occupations, Distributed According to Establishment's Number of Vacancies and Vacancy Rate

A. Distribution according to number of vacancies in establishment

Number of vacancies	Number of establishments	Number of persons in technical occupations	Number of vacancies	Average vacancy rate
All establishments	14,595	148,684	4,562	3.1
Those without vacancies	13,318	99,089	xx	xx
Those with vacancies[a]	1,277	49,595	4,562	9.2
Number of vacancies:				
1	635	6,557	635	9.7
2	246	5,148	492	9.6
3	100	3,313	300	9.1
4	84	2,633	336	12.8
5	41	2,545	205	8.1
6	36	2,443	216	8.8
7	18	1,391	126	9.1
8	25	2,744	200	7.3
9	15	1,436	135	9.4
10	14	2,362	140	5.9
11	7	477	77	16.1
12	5	670	60	9.0
13	6	554	78	14.1
14	5	393	70	17.8
15-19	11	1,550	182	11.7
20-29	11	3,267	251	7.7
30-39	7	1,635	225	13.8
40-49	3	1,319	134	10.2
50 or more	8	9,158	700	7.6

(continued)

Table R. Establishments with Technical Occupations and Workers in Those Occupations, Distributed According to Establishment's Number of Vacancies and Vacancy Rate (*continued*)

B. Distribution according to vacancy rate of establishment

Number of vacancies	Number of establishments	Number of persons in technical occupations	Number of vacancies	Average vacancy rate
All establishments	14,595	148,684	4,562	3.1
Those without vacancies	13,318	99,089	xx	xx
Those with vacancies[a]	1,277	49,595	4,562	9.2
Vacancy rate (percent):				
0.1- 9.9	389	37,682	1,748	xx
10.0- 19.9	222	7,046	933	xx
20.0- 20.9	57	698	140	xx
21.0- 24.9	35	1,100	242	xx
25.0- 25.9	45	326	82	xx
26.0- 29.9	13	386	104	xx
30.0- 32.9	6	286	86	xx
33.0- 33.9	78	318	106	xx
34.0- 39.9	7	244	90	xx
40.0- 40.9	34	200	80	xx
41.0- 49.9	31	425	184	xx
50.0- 50.9	96	312	156	xx
51.0- 59.9	3	39	21	xx
60.0- 69.9	17	101	66	xx
70.0- 99.9	10	55	44	xx
100.0-100.9	160	247	247	xx
101.0-199.9	10	78	100	xx
200.0-200.9	39	42	84	xx
201.0 or more	6	10	30	xx
Vacancies, but no persons in technical occupations	19	—	19	xx

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[a] Distributions in A and B are of these establishments, their personnel in technical occupations, and their vacancies.

IV. SOURCES OF WORKERS

Employers have two methods of obtaining qualified workers in technical occupations. They can upgrade existing employees, or they can recruit workers, hiring them from outside the establishment.

Upgrading means that jobs are filled by promotion, or by moving up persons from jobs of lesser skill level or responsibility.[1] The employer may or may not have an organized training program to back up or accelerate the upgrading process. Organized training in this context means a prearranged training program organized or utilized by the employer in which a course of instruction and/or job training is carried out in the employer's establishment and/or in a school. This includes, among others, apprentice-type training, school course work arranged by the employer, plans that refund the tuition for a school course, and school-plant cooperative work programs. Organized training for a job may take place before the employee is assigned to it; or it may take place after assignment, in which case he may be designated a trainee.

Upgrading without organized training takes place where an employer does not arrange any formal training activity but upgrades whoever has been able to qualify himself by learning on the job or by school work that he himself arranged for. The job experience may be obtained in a different but related kind of work, such as work in a craft. In an establishment with a multi-grade structure experience for a higher grade is typically obtained through work in a lower grade.

When he uses the recruitment method, the employer hires persons already qualified to perform the basic responsibilities of the job, though an orientation and breaking-in period on the job may be needed. The employer may recruit directly from schools, high schools with technical curriculum, technical institutes, and colleges; by advertising; through employment agencies; by referrals from his present workers; etc. A person hired from the outside into a technician-trainee job from which he advances to the technician level more or less automatically with passage of time (provided he passes probation satisfactorily) also is considered to have been obtained by recruitment.

This survey sought to determine the proportion of workers obtained from each source during the two-year period preceding the survey or during some current period that the employer considered more representative.

OVER-ALL PICTURE

Taking data for all grades together, about 57 percent of technical employees were obtained by recruitment from outside the firm. Among the others—who achieved their jobs as a result of upgrading—only a few had had organized training:

Both methods	100.0%
Recruitment	57.4
Upgrading, total	42.6
With organized training	5.8
Without organized training	36.8

In the upper grades of technical occupations having a multi-grade structure, upgrading, as might be expected, was the predominant though by no means the only method of obtaining workers. Part A of table S shows the differences among the grades (further detail will be found in table 28 in supplement A to volume 1).

OCCUPATIONAL PATTERNS

In most of the technical occupation groups, recruitment from outside the firm is the most usual method of obtaining workers, but in the important electro and mechanical engineering group and in the industrial engineering, product testing and inspecting, data-processing, and airway tower specialist groups, upgrading is more important. (Part B of table S, based on table 28 in supplement A to volume 1.) In part, these exceptions are explained by the fact that in these occupations relatively large numbers work at the supervisory level or work in multi-grade systems, where upgrading is the usual method of obtaining workers for the upper levels. In part they may be explained by other factors—they may, for example, be related to the availability and adaptability for upgrading into technical jobs of persons in other, nontechnical lines of work, especially craft and other production and maintenance jobs.

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[1] Some workers are shifted or transferred into technical occupations from technical or nontechnical jobs at the same general skill level. For purposes of this report, these transfers are included under the heading of upgrading.

INDUSTRY DIFFERENCES

In all but two industry divisions, more than half the workers in technical occupations are recruited from outside the establishments. The industries that rely most heavily on outside recruitment to obtain technical workers tend to have a large proportion of small establishments employing nonunionized workers. In contrast, the two industry divisions that depend more on upgrading—manufacturing and transportation, communication, and public utilities—have a number of large firms with substantial numbers of unionized technical workers. (Part C of table S, based on table 30 in supplement A to volume 1.)

COLLEGE AND TECHNICAL-INSTITUTE GRADUATES

Another aspect of the sources of workers in technical occupations is reflected in the education and experience of workers already employed. While it was

Table S. Percent Distribution of Workers in Technical Occupations According to Method of Obtaining Them
(A) By Grade, (B) By Occupation Group, and (C) By Industry Division

Grade; occupation group	Both methods	Recruited from outside the firm	Upgraded	
			With training	Without training
All grades; all occupations; all industries	100.0	57.4	5.8	36.8
A. Grade				
Supervisory grades	100.0	19.3	8.2	72.5
Nonsupervisory grades:				
Single grade only	100.0	72.9	6.2	20.9
Multi-grade				
Lowest grades	100.0	68.1	3.5	28.4
Middle grades	100.0	31.6	7.4	61.0
Highest grades	100.0	27.9	6.9	65.2
Grading system not reported	100.0	31.1	0.4	68.5
B. Occupation group				
Draftsmen	100.0	69.0	2.5	28.5
Structural design technicians and related specialists	100.0	51.7	0.7	47.6
Electro and mechanical engineering technicians	100.0	42.1	10.0	47.9
Mathematics technicians	100.0	60.9	1.0	38.1
Physical science technicians	100.0	52.3	2.0	45.7
Biological, medical, dental, and related science technicians	100.0	81.5	1.2	17.3
Industrial engineering technicians and related specialists	100.0	36.6	14.3	49.1
Civil engineering and construction technicians and specialists	100.0	60.5	2.8	36.7
Sales and service technicians	100.0	74.0	1.1	24.9
Technical writing and illustration specialists	100.0	66.4	0.7	32.9
Safety and sanitation inspectors and related specialists	100.0	66.3	2.7	31.0
Product testing and inspection specialists	100.0	47.1	1.9	51.0
Data-processing systems analysis and programming specialists	100.0	49.3	10.9	39.8
Airway tower specialists and flight dispatchers	100.0	11.6	79.2	9.2
Broadcasting, motion picture, and recording studio specialists	100.0	74.1	0.5	25.4
C. Industry division				
Manufacturing	100.0	46.3	2.6	51.1
Construction	100.0	68.4	1.5	30.1
Transportation, communication, and public utilities	100.0	42.1	16.9	41.0
Private medical services	100.0	86.9	1.4	11.7
Research laboratories, etc.[a]	100.0	71.9	0.5	27.6
Private colleges and schools	100.0	71.8	0.0	28.2
Government	100.0	50.7	18.3	31.0
All other	100.0	72.6	4.2	23.2

[a] Research, development and testing laboratories; engineering and architectural services; and business and management consulting services.

not feasible to obtain comprehensive information of this kind in the present survey, it was possible to ascertain how many were college graduates and technical-institute graduates. Some of the graduates completed their course after they were hired.

"College" here means a school granting a degree after four or more years of study. "Technical institute" means any one-year, two-year, or three-year post-high-school technical instruction program at a public or private institution, including a community college. Completion of such courses does not necessarily result in an "associate" degree being conferred. Some private institutes do not give associate degrees. No effort was made to determine whether the course of college or technical institute study was directly related to work being performed at the time of the survey.

The data shown here should be taken as estimates and not precise counts, since many employers estimated the proportion of job holders who were college and technical-institute graduates rather than referring to personnel records or contacting the individuals involved.

Table T. Percent of Persons in Technical Occupations Who Are College Graduates and Percent Who Are Technical-Institute Graduates (A) By Grade and (B) By Occupation Group

Grade level; technical occupation group	College graduates	Technical-institute graduates
All technical occupations, all grades	12.9	28.5
A. Grade		
Supervisory grades	21.2	27.9
Nonsupervisory grades:		
Single grade	13.6	28.2
Multi-grade structure:		
Lowest grades	10.4	25.9
Middle grades	12.6	31.1
Highest grades	13.7	31.9
Grading system not reported	3.4	24.9
B. Technical occupation group		
Data-processing systems analysis and programming specialists	63.5	4.7
Technical writing and illustration specialists	32.8	28.4
Structural design technicians and related specialists	26.3	33.0
Broadcasting, motion picture, and recording studio specialists	7.0	50.8
Biological, medical, dental, and related science technicians	21.3	33.1
Mathematics technicians	30.8	19.7
Sales and service technicians	34.0	16.2
Physical science technicians	11.2	35.9
Draftsmen	9.2	33.9
Civil engineering and construction technicians and specialists	13.6	25.4
Industrial engineering technicians and related specialists	8.7	25.5
Electro and mechanical engineering technicians	2.2	30.6
Airway tower specialists and flight dispatchers	1.5	31.0
Safety and sanitation inspectors and related specialists	17.2	8.0
Product testing and inspection specialists	1.8	10.2

Employers reported that over 40 percent of the workers in technical occupations were college or tech- an understatement, in part because reporting was incomplete and in part because a person who took such nical-institute graduates. The proportion is somewhat greater at the higher-grade levels than at the lower ones (see part A of table T, whose data are taken from table 32 in supplement A to volume 1). Among the fifteen occupation groups the proportion varies from 68 percent for data-processing systems analysis and programming specialists to 12 percent for product testing and inspection specialists (see part B of table T, also based on table 32).

Among the different industries, half or more of the persons employed in technical occupations in private medical services, in research laboratories and engineering services, in private colleges and schools, and in construction are graduates of a college or technical institute. There are relatively few graduates in technical occupations in transportation, communication, and public utilities.

Taking college graduates alone, private colleges and schools have the largest proportion by far (47 percent) of such graduates among the persons working for them in technical occupations. Of these college graduates working for private colleges and schools, 59 percent are biological or medical technicians, and an additional 23 percent are working as physical science technicians. Substantial proportions of these employees are part-time graduate students, some of whom receive free tuition or a tuition reduction in addition to wages. Some are recent graduates developing a competence in the field of research. (Tables 34 and 35 in supplement A to volume 1.)

ARMED FORCES SCHOOL GRADUATES

An effort was made to find out how many electro and mechanical engineering technicians had completed course programs in technical fields while in service with the armed forces. The number found is probably a course and also was a graduate of a technical institute or college was counted under the latter heading rather than under the former. The understatement may be reduced by the likelihood that some employers incorrectly reported as graduates of armed forces schools persons who had served in a technical capacity in the armed forces as a result of their previous schooling or experience as civilians.

The various types of electro and mechanical engineering technician may be compared with respect to the relative frequency of training in the armed forces by means of the present data, whether or not the data understate the absolute number. Table U shows that nine out of ten (91 percent) of the 3,673 reported to

Table U. Distribution by Field and Function of Graduates of Armed Forces Schools Who are Electro and Mechanical Engineering Technicians

(Also, percent that those in each field or function are of its total technical employment)

Field by function	Number	Percent distribution	Percent of total
All fields	3,673	100.0	8.7
Design	34	0.9	0.4
Development	298	8.1	2.5
Troubleshooting and related	3,341	91.0	14.9
Electronic	1,104	30.1	10.2
Design	—	—	—
Development	191	5.2	3.9
Troubleshooting and related	913	24.9	16.8
Electrical	507	13.8	5.8
Design	27	0.7	2.7
Development	80	2.2	3.2
Troubleshooting and related	400	10.9	7.6
Mechanical	59	1.6	0.7
Design	4	0.1	0.1
Development	13	0.4	0.6
Troubleshooting and related	42	1.1	2.2
Electro-mechanical	2,003	54.5	14.3
Design	3	0.1	0.2
Development	14	0.4	0.6
Troubleshooting and related	1,986	54.0	20.3

have had this training are performing troubleshooting and related functions—three-fifths are in the electro-mechanical field and more than a quarter in the field of electronics. About 20 percent of all electro-mechanical troubleshooting technicians and 17 percent of electronics troubleshooters are graduates of armed forces schools.

Of the remaining 9.0 percent, who are not in troubleshooting, the largest number (8.1 percent) are in development; only a few (0.9) in design.

It has already been indicated that the electro-mechanical and electronic fields predominate. About 14 percent of the technicians who are graduates of armed forces schools are employed in the electrical field and only about 2 percent in the mechanical field.

POST-HIGH-SCHOOL EDUCATION ACHIEVED

Around 60 percent of all persons employed in technical occupations in New York State in 1962 had some post-high-school technical course work. This is an estimate that includes not only those who graduated from technical institutes or college programs and those who attended such institutions but did not graduate, but also those who graduated from armed forces schools and apprenticeship programs. These figures probably do not reflect all persons who have done some incidental study beyond high school, as through a correspondence course or two.

The proportion of employees having some post-high-school education varies widely among the different groups of technical occupations, ranging from an estimated 88 percent in the case of technical writers to an estimated 18 percent in the case of product testing and inspection specialists:

Technical occupation group	*Range*[a]	*Mid-point of range*
All technical occupations	58-63	61
Draftsmen	65-70	68
Structural design technicians and related specialists	80-85	83
Electro and mechanical engineering technicians	55-60	58
Mathematics technicians	80-85	83
Physical science technicians	65-70	68
Biological, medical, dental, and related science technicians	65-70	68
Industrial engineering technicians and related specialists	55-60	58
Civil engineering and construction technicians and specialists	50-55	53
Sales and service technicians	75-80	78
Technical writing and illustration specialists	85-90	88
Safety and sanitation inspectors and related specialists	30-35	33
Product testing and inspection specialists	15-20	18
Data-processing systems analysis and programming specialists	75-80	78
Airway tower specialists and flight dispatchers	60-65	63
Broadcasting, motion picture, and recording studio specialists	70-75	73

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[a] Range: from lowest estimate to highest estimate.

The estimates were made by the use of the survey data on the number of persons who graduated from a college or technical institute and the survey data on employers' requirements of, and preferences for, post-high-school education of various types and levels. The first data yielded the number of persons in technical occupations who had achieved the level of graduation. The number who were not graduates but had had some post-high-school education was estimated from the relationships between the data on requirement of graduation and preference for graduation and the number of actual graduates.

V. EDUCATION AND EXPERIENCE REQUIREMENTS

Nearly all employers require at least high-school graduation as a condition of employment in technical occupations. The number who do not require it is so small as to be negligible.[1]

Some formal post-high-school education is required in the case of nearly half of all workers in technical jobs, and some related work experience in the case of three-fourths (required especially frequently in the higher grades).

Employers were asked to report, for each of their technical occupations, the required qualifications in respect to formal education and work experience that were in effect at the time of the survey. They were asked to indicate (a) what qualifications were *required* and (b) what qualifications they would have *preferred* (presumably, reasonable and not unattainable preferences). The qualifications in question were those needed by new entrants into the job, at the given grade, whether they came by recruitment or by upgrading. Included were qualifications for trainee jobs, in those cases in which a trainee's advancement to full job status was automatic after probation was satisfactorily served.

Note that these requirements do not reflect education called for after appointment to the job—for example, the employer may require that the worker take a course of study in the local high school or technical institute.

Required education was considered to be the least amount of education recognized by the employer for the job in question. Experience was the amount, if any, required as a supplement to that minimum required level of education. The level of education that the employer would have liked to demand (and the minimum amount of experience that went with it) was noted as the preferred level only if the employer specifically stated a preference. Otherwise his required level was considered to be his preferred level, too.

The following classifications of (A) education and (B) experience (whether requirement or preference) were used in tabulating employers' responses:

A. EDUCATION

(1) Post-high-school education

(a) Engineering college: graduation
less than graduation

(b) General four-year college: graduation
less than graduation

(c) Technical institute: graduation
less than graduation

This category includes one-year, two-year, and three-year technical institutes, public or private. It includes the technical programs of community colleges.

(d) Post-high-school education, type not specified

This category applies mainly to references to post-high-school education in cases where the employer's reply did not specify the type of educational institution or program. Examples of requirements classified here are "two years of post-high-school education," "high-school graduation and a course in drafting after high school," and "technical course beyond high school."

Note that such work is not necessarily at a technical institute or college level, although usually this would be true. Furthermore, work that is given only in post-high-school institutions in one area may be given in high schools in another area, depending on the degree of specialization and quality of course work offered.

(e) Apprenticeship or armed forces schools

This category includes completion of a formal apprenticeship training program and completion of a technical training program of the armed forces.

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[1] Roughly 2 percent of all persons in technical occupations work for employers who do not require high-school graduation. Most of these employers reported that their only criterion in hiring was proof that the applicant was "able to do the job," for example, evidence of previous experience in a related craft or the results of a test administered. In this report such cases are assumed to be in the high-school-graduation-required category.

(2) High school

(a) Technical or vocational

This category includes those cases in which the employer specified graduation from a technical or vocational high school. Numbers reported here may be understated because employers were not always asked, where they did not volunteer the information, whether they were referring to technical and vocational or other high school.

(b) Other

This refers to the general high school, and to cases in which the employer simply said "high school."

Some employers reported that the education requirements they had specified were set at a level above what was essential to perform the job in question. However, this kind of overstatement is to be found only in a limited number of cases, judging by the following data, which show, for four important occupations, the total number of employers reporting and the percent of these who indicated that they had overstated requirements:

Technical occupation group	*Number of establishments*	*Percent overstating*
Electro and mechanical engineering technicians	1,303	5
Draftsmen	1,088	5
Industrial engineering technicians	548	3
Physical science technicians	428	4

As to reasons for overstating educational requirements, most employers said in effect that the margin of educational attainment above the level actually needed to perform the job gave some additional assurance that the work would be well done and that the new employee had a potential for growth, development, and promotion.

B. EXPERIENCE

The following eight categories were used in classifying employers' responses as to experience required:

None (no experience)
1 and under 2 years
2 and under 3 years
3 and under 4 years
4 and under 5 years
5 and under 7 years
7 and under 10 years
10 years and over

The exact amount of experience needed was left unspecified by the employer in the case of approximately 8 percent of all employees in technical specifications. These persons were allocated among the amount-of-experience categories in accordance with the proportions found in the replies of other employers, in relation to levels of education specified by employers for the given occupation and grade.

These groupings of education and experience were used in recording both the requirements and the preferences of employers.

In many cases employers expressed no preferences. Where they did express one, they had usually set their requirement below their preference because they could not find applicants who met their preferred or optimum qualifications (either in an absolute sense or in terms of the salary they were willing to pay).

One may ask why four-year-college graduation is recognized as an educational requirement for technical occupations in view of the fact that technical occupations generally are supposed to be at a subprofessional level that does not really require college graduation. The answer is two-fold: (1) In most technical occupations at least a few employers require college graduation, even though the vast majority do not. (2) There are certain jobs on the margin between technical and professional that were included in the survey as a unit; that is, all personnel employed in these jobs were included regardless of whether or not they were professional or subprofessional (see above, chapter I, pages 5 and 6). These jobs include technical writers and illustrators, data-processing systems analysis and programming specialists, medical record librarians, medical "technologists," and therapists.

REQUIRED AND PREFERRED EDUCATION

Employers of 47 percent of all persons in technical occupations require some post-high-school education as a condition of employment in these occupations. Employers of the remaining 53 percent have educational requirements that do not go beyond completion of high school.

Of the technical workers in jobs for which post-high-school education is required, by far the largest concentration work for employers whose minimum requirement is graduation from a technical institute or community college—it is required for 21 percent of all technical-level jobs. For 8 percent of all technical workers the requirement is college graduation (4 or more years). Some college or technical-institute attendance, though not graduation, is required for another 8 percent of the total, while apprenticeship or armed forces technical-school graduation is specified for 3 percent. (See following table V, based on table 36 in supplement A to volume 1.)

Table V. Distribution of Persons in Technical Occupations According to Level of Education Required

Education required	Number	Percent
All levels	148,684	100.0
Post-high-school	69,554	46.8
Engineering college	5,788	3.9
Graduation	2,200	1.5
Less than graduation	3,588	2.4
College, general	14,017	9.4
Graduation	9,702	6.5
Less than graduation	4,315	2.9
Technical institute	34,574	23.3
Graduation	30,803	20.8
Less than graduation	3,771	2.5
Type not specified	10,563	7.1
Apprenticeship or armed forces school	4,612	3.1
High school	79,130	53.2
Technical or vocational	11,376	7.7
Other	67,754	45.5

The requirement of or preference for post-high-school education reflects not only a need for more intensive training than can be obtained in the typical high school but also, in some instances, the desire for older, more mature individuals.

There are wide differences among the technical occupations in respect to employers' minimum educational requirements. Requirement of some kind of post-high-school education varies from 81 percent of the personnel in the mathematics technician group to 4 percent in the case of product testing and inspection specialists and 2 percent in the case of airway tower specialists and flight dispatchers. (Table W, based on table 36 in supplement A to volume 1, which gives percents for each level of education. See also tables 41 and 42, which give percents by area and by industry division.)

Table W. Percent of Persons in Each Technical Occupation Group for Whom Employer Required Some Education Beyond High School

Technical occupation group	Number[a]	Percent
All technical occupations	148,684	46.8
Mathematics technicians	831	81.2
Data-processing systems analysis and programming specialists	6,153	68.1
Technical writing and illustration specialists	3,034	64.9
Broadcasting, motion picture, and recording studio specialists	2,920	62.3
Physical science technicians	8,969	62.1
Structural design technicians and related specialists	2,516	56.4
Electro and mechanical engineering technicians	42,031	56.2
Sales and service technicians	1,932	53.8
Biological, medical, dental, and related science technicians	25,445	51.7
Industrial engineering technicians and related specialists	6,901	45.0
Draftsmen	20,972	40.0
Civil engineering and construction technicians and specialists	13,464	27.2
Safety and sanitation inspectors and related specialists	4,084	14.6
Product testing and inspection specialists	8,059	4.1
Airway tower specialists and dispatchers ..	1,373	2.3

[a] Total number in occupation.

The airway tower specialists are a special case. Most are employed by the federal government, which admits persons with no education beyond high school into this occupation if they have had several years of related experience and if they pass a special test. Successful applicants go into a trainee category.[1]

It may be noted that the federal Civil Service's minimum requirement for technical occupations generally is high-school graduation plus one or more years of experience. Education beyond high school may be substituted for experience; no preference is expressed by Civil Service. A Civil Service formula for substitution of education for experience is as follows:

(1) High-school graduation:
It may be substituted for 6 months of general experience.

(2) High-school graduation, including courses in science, mathematics, or engineering:
It may be substituted for 1 year of general experience.

(3) Pertinent courses in a technical institute, or technical courses in another school above high school:
Usually 1 month of full-time study may be substituted for 1 month's experience up to a maximum of 6 months, 1 year, 2 years, or 3 years, depending on the occupation.

(4) Undergraduate study in an accredited college, including courses in science, mathematics, or engineering:
Usually 1 year of schooling may be substituted for 9 months or 1 year of experience.

The proportion of workers for whom some post-high-school education is required rises from 46.8 to 51.6 percent if government agencies are removed and the data are limited to nongovernmental employees; the high-school category drops correspondingly from 53.2 to 48.4 percent. Similar changes take place in all but one of the occupation groups, as the following figures show:

Technical occupation	*Percent of workers for whom post-high-school education is required*	
	Including government	*Excluding government*
All technical occupations	46.8	51.6
Draftsmen	40.0	41.8
Structural design	56.4	56.8
Electro and mechanical engineering	56.2	58.8
Mathematics	81.2	82.2
Physical science	62.1	64.0
Biological, medical, and related	51.7	53.2
Industrial engineering	45.0	53.9
Civil engineering and construction	27.2	40.9
Sales and service	53.8	55.1
Technical writing and illustrating	64.9	65.8
Safety and sanitation	14.6	33.4
Product testing and inspection	4.1	3.9
Data processing	68.1	71.3
Airway tower specialists and flight dispatchers	2.3	12.4
Broadcasting, motion picture, and recording studios	62.3	64.5

In practice, government agencies are able to obtain persons with educational attainment substantially above minimum-requirement levels. About 18 percent of all technical workers in government are required to have some post-high-school education, but about 40 percent are graduates of a college or a technical institute.

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[1] Table T (in chapter IV, above) shows that 31 percent of these persons are in fact technical-institute graduates and that some are college graduates. For detail on the occupation, see volume 2, chapter XIV.

Many employers who said they required high-school education stated that they preferred to have some amount of post-high-school education. As compared to 47 percent on a required basis, 65 percent of personnel in technical occupations worked for employers who preferred some post-high-school education. Specifically, technical-institute graduation went from 21 percent on a required basis to 31 percent on a preferred basis; college graduation (four or more years) went from 8 percent to 17 percent. (See adjacent table X, based on tables 36 and 37 in supplement A to volume 1, which give data by technical occupation group.)

One would expect to find the actual educational background of persons in technical jobs to be at a higher level than the minimum educational requirements that employers had established for the jobs. On the other hand, one would expect employers' educational preferences to exceed the educational attainments of persons employed.

Table X. Education Required and Education Preferred

(Percent distribution of persons in technical occupations according to level of education specified by employer)

Level of education	Required	Preferred
All levels	100.0	100.0
Post-high-school	46.8	65.4
Engineering college	3.9	8.3
Graduation	1.5	6.0
Less than graduation	2.4	2.3
College, general	9.4	14.3
Graduation	6.5	10.5
Less than graduation	2.9	3.8
Technical institute	23.3	33.0
Graduation	20.8	31.1
Less than graduation	2.5	1.9
Type not specified	7.1	6.8
Apprenticeship or armed forces school	3.1	3.0
High school	53.2	34.6
Technical or vocational	7.7	5.5
Other	45.5	29.1

Table Y. Graduation from (A) College and (B) Technical Institute: Percent of Persons in Each Technical Occupation Group as to Whom Employer Requires Graduation, Percent as to Whom He Prefers it, and Percent Who are Graduates

Technical occupation group	Graduation required		Graduation preferred		Percent who graduated	
	College	Institute	College	Institute	College	Institute
All technical occupations	8.0	20.8	16.5	31.1	12.9	28.5
Data-processing systems analysis and programming specialists	52.5	3.1	73.3	2.0	63.5	4.7
Physical science technicians	8.1	36.0	13.3	46.6	11.2	35.9
Biological, medical, dental, and related science technicians	18.2	24.7	25.5	28.1	21.3	33.1
Technical writing and illustration specialists	23.9	18.4	42.2	17.8	32.8	28.4
Electro and mechanical engineering technicians	0.7	30.3	4.8	46.7	2.2	30.6
Industrial engineering technicians and related specialists	2.1	24.5	11.6	26.6	8.7	25.5
Mathematics technicians	13.3	12.3	39.8	11.8	30.8	19.7
Sales and service technicians	12.8	10.6	50.4	15.3	34.0	16.2
Structural design technicians and related specialists	8.3	11.9	40.9	20.3	26.3	33.0
Draftsmen	3.2	15.7	9.9	32.5	9.2	33.9
Civil engineering and construction technicians and specialists	5.3	11.5	20.2	16.9	13.6	25.4
Broadcasting, motion picture, and recording studio specialists	0.7	11.9	2.9	54.6	7.0	50.8
Safety and sanitation inspectors and related specialists	3.5	4.4	18.3	4.5	17.2	8.0
Product testing and inspection specialists	0.6	1.7	1.8	12.7	1.8	10.2
Airway tower specialists and flight dispatchers	—	0.9	0.7	1.6	1.5	31.0

The data indicate that, as measured by college and technical-institute graduation, educational attainment falls between employers' requirements and preferences, on an over-all basis. This is also true within most of the fifteen occupation groups. The record in this respect is more consistent with respect to college graduation than technical-institute graduation, where attainment runs ahead of preference in the majority of occupation groups. (See percentage figures in table Y, and corresponding rankings of occupational groups in table Z.)

EXPERIENCE REQUIREMENTS

In reporting the amount of experience that employers require for employment in technical occupations, tables AA, BB, and CC show it both on the basis of the number of jobs to which the requirements apply and on the basis of the number of workers in those jobs.[1]

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[1] Each grade within each technical occupation is counted as a separate job for this purpose, a single-grade occupation being counted just once in a given establishment. There were 37,731 such jobs (occupation-grade units) in the 14,595 establishments having technical occupations.

Table Z. Graduation from College or Technical Institute: Ranking of Technical Occupation Groups According to Percent of Workers for Whom Employer Requires it, Percent for Whom He Prefers it, and Percent of Graduates[a]

Technical occupation group	Requirement	Preference	Graduation
Data-processing systems analysis and programming specialists	1	1	1
Physical science technicians	2	5	8
Biological, medical, dental, and related science technicians	3	7	5
Technical writing and illustration specialists	4	4	2
Electro and mechanical engineering technicians	5	9	12
Industrial engineering technicians and related specialists	6	11	11
Mathematics technicians	7	8	6
Sales and service technicians	8	2	7
Structural design technicians and related specialists	9	3	3
Draftsmen	10	10	9
Civil engineering and construction technicians and specialists	11	12	10
Broadcasting, motion picture, and recording studio specialists	12	6	4
Safety and sanitation inspectors and related specialists	13	13	14
Product testing and inspection specialists	14	14	15
Airway tower specialists and flight dispatchers	15	15	13

[a] See table Y.

The kind of work experience required in most cases is experience in a type of work that is related to the job under consideration. Usually this means work that helps develop relevant technical skills; knowledge of engineering, science, or technology; and/or knowledge of the company's products, equipment, or processes. It may be experience in lower-grade levels of the same kind of jobs. In some cases, especially in simpler kinds of technical work, only general work experience is required. A general reason for the work-experience requirement is the evidence it affords concerning an applicant's capacity for work and his work habits.

A requirement of some experience as a condition of employment at the minimum acceptable level of educational attainment was reported for about two-thirds of the jobs, covering almost three-quarters of the workers in technical occupations. Table AA shows how frequently the requirement was one year, two years, etc., when all levels of technical occupation (and all levels of required education) are combined. (As might be expected, the occupation groups differ considerably as to experience requirements. See table 38 in supplement A to volume 1, and chapters on various groups in volume 2.)

For all technical jobs combined, the average number of years of experience required is 2.3 years. This figure is slightly more when the data are weighted by the number of persons employed in the various technical jobs. (Table BB.)

The average of the experience requirements is greatest for supervisory grades and, in every occupation group but one, it steadily increases with the increase in grade level. Within occupation groups, there is a somewhat stronger relationship between grade steps and years of experience required than there is between grade steps and minimum amount of education required. (See table BB, which makes the comparison for all occupations combined. Corresponding data on each of the 15 occupation groups will be found in tables 40 and 43, in supplement A to volume 1. Table BB's data are given on the basis of both jobs and workers; so are the data of tables 40 and 43.)

The number of years of experience required of applicants for technical jobs is related to the level of education required for these positions. Among establishments reporting that some education beyond high school was a prerequisite for employment, the average experience required was 1.4 years, over-all, while those willing to accept persons with a high-school education required 2.9 years. Accordingly, it seems that post-high-school education on the average is considered

Table AA. Experience Employers Require for Technical Occupations

(Percent distribution by years of experience, and cumulative percent)

Experience required	In terms of jobs[a]		In terms of workers	
	Percent distribution	Cumulative percent	Percent distribution	Cumulative percent
Total	100.0	xx	100.0	xx
No experience	32.1	32.1	26.5	26.5
Under 1 year	2.6	34.7	3.4	29.9
1 and under 2 years	11.5	46.2	10.6	40.5
2 and under 3 years	13.2	59.4	15.0	55.5
3 and under 4 years	10.3	69.7	10.8	66.3
4 and under 5 years	6.7	76.4	8.1	74.4
5 and under 7 years	14.1	90.5	16.9	91.3
7 and under 10 years	4.6	95.1	4.6	95.9
10 years and over	4.9	100.0	4.1	100.0

[a] Each grade within each technical occupation is counted as a separate job for this purpose, a single-grade occupation being counted just once in a given establishment. There were 37,731 such jobs (occupation-grade units) in the 14,595 establishments having technical occupations.

Table BB. Education and Experience Employers Require for Technical Occupations, by Grade

Grade	In terms of jobs[a]		In terms of workers	
	Median years of experience	Percent requiring post-high-school education	Median years of experience	Percent requiring post-high-school education
All grades	2.3	45.9	2.6	46.8
Supervisory grades	5.9	49.0	6.2	44.4
Nonsupervisory grades:				
Single grade only[b]	1.4	45.3	1.9	48.1
Multi-grade:				
Lowest grades	1.6	39.2	1.9	36.1
Middle grades	3.1	49.1	3.4	52.8
Highest grades	4.1	49.9	4.7	50.9

[a] See footnote of table AA.
[b] Includes workers and jobs for which grades were not reported.

equivalent to around a year and a half of work experience.

The corresponding figures for each of the 15 occupation groups are shown in table CC (based on table 43 in supplement A to volume 1).

About 27 percent of the persons in technical occupations work for employers who require *no previous work experience* as a condition of employment. This is more likely to be true of employers requiring some post-high-school education. These reported that no experience is required in respect to 37 percent of their technical workers' jobs—compared with 17 percent in the case of employers requiring no education beyond high school. The proportions vary greatly among the various occupation groups. No experience is required for less than 2 percent of the airway tower specialists, post-high-school education being the only requirement. On the other hand, more than half (54 percent) of the mathematics technicians need no experience (58 percent where post-high-school education is required and

Table CC. Median Years of Experience Employers Require in Each Technical Occupation Group as Supplement to Requirement of (A) High-School and (B) Post-High-School Education

(Also percent of workers in each group for whose jobs no experience is required)

Technical occupation group	Median years of experience						Percent of technical workers for whose job no experience is required		
	In terms of jobs[a]			In terms of workers					
	Total	Post-high-school	High school	Total	Post-high-school	High school	Total	Post-high-school	High school
All technical occupations	2.3	1.4	2.9	2.6	1.9	3.4	26.5	37.4	16.8
Draftsmen	2.2	1.2	2.7	2.4	1.6	2.8	31.1	40.5	24.7
Structural design technicians and related specialists	5.7	4.4	7.2	6.4	5.6	7.7	13.8	21.0	4.4
Electro and mechanical engineering technicians	3.8	3.1	4.9	3.4	2.6	4.8	18.1	27.8	5.7
Mathematics technicians	1.5	1.0	1.9	0.0	0.0	1.7	54.1	58.4	35.9
Physical science technicians	2.0	1.6	2.5	2.3	1.9	2.7	28.6	32.3	22.9
Biological, medical, dental, and related science technicians	0.0	0.0	1.2	0.2	0.0	1.6	49.2	62.2	35.4
Industrial engineering technicians and related specialists	3.9	2.8	4.9	3.9	3.3	4.9	13.2	21.9	6.1
Civil engineering and construction technicians and specialists	4.5	2.3	5.5	4.4	1.5	5.1	19.5	46.6	9.4
Sales and service technicians	3.4	1.9	5.4	3.2	0.0	4.0	29.2	53.7	1.0
Technical writing and illustration specialists	3.2	2.9	3.9	2.8	2.6	3.2	13.6	19.2	3.4
Safety and sanitation inspectors and related specialists	4.6	2.2	5.3	4.7	2.1	5.2	17.6	38.1	14.0
Product testing and inspection specialists	1.9	0.0	1.9	1.9	1.1	2.0	24.1	44.9	23.3
Data-processing systems analysis and programming specialists	3.3	2.8	3.9	2.3	2.0	3.6	28.3	35.8	12.5
Airway tower specialists and flight dispatchers	6.4	[b]	6.6	5.2	0.0	5.3	1.7	77.4	0.0
Broadcasting, motion picture, and recording studio specialists	2.6	2.7	2.4	2.4	2.5	2.0	13.4	11.3	17.0

[a] See footnote of table AA.
[b] Not computed because of small number involved.

36 percent where it is not required). The figures for other occupation groups are shown in the last columns of table CC; they are based on table 39 in supplement A to volume 1, which also gives data by grade.

Generally, this picture of less experience where post-high-school education is required holds up for the various occupation groups and grade levels (table 43 in supplement A to volume 1). However, some exceptions show up in the data. The main explanation of these abnormal relationships (no difference in the average experience requirement as between post-high-school and high-school requirements, or more years of experience for post-high-school students than for high-school students) is that the occupational classification includes two or more substantially different types of jobs—in which the more advanced job requires both more education and more experience than the lower-level job does. (For examples, see volume 2, chapter V, "Physical Science Technicians.")

For single grades and for beginning grades in multi-grade structures, around two years of work experience is required for high-school graduates, on the average, compared to a year or less where post-high-school education is a prerequisite for employment. This is seen in the following figures:

	Single grades[a]	*Lowest grades in multi-grade structures*
Median years of experience required:		
Where post-high-school education is required	0.0	0.9
Where high school is required	2.3	2.1
Total	1.4	1.6

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[a] Includes jobs for which grades were not reported.

A comparison of employers' education and experience *requirements* with their *preferences* as to education and experience indicates that the most common preference was for more education and (if necessary) less experience; that is, if employers had a choice they would give up experience for more education. This is seen in the following percentage figures, taken from table 44 in supplement A to volume 1; they are in terms of number of technical occupation employees:

Kind of preference	*All workers in technical occupations*	*Those for whom high school is required*
Total	100.0	100.0
No preference	66.0	58.9
All cases with preference	34.0	41.1
Required education, more experience	4.5	2.9
More than required education, less experience	15.0	22.6
More than required education, same experience	11.4	12.2
More than required education, more experience	3.1	3.4

This does not mean that employers uniformly preferred education to experience or were always willing to exchange more education for experience. An analysis of replies to the question—

> Are the skills gained by the work experience that is required the kind that could be taught by school class work?

suggests that a substantial proportion if not a majority of employers of technicians believe that the values of work experience are unique and cannot be replaced by school course work.

The following results were found in an analysis of employer replies to this question with respect to seven leading technical occupation groups:

Technical occupation group	*Employers reporting*	*Percent answering "No"*
Electro and mechanical engineering technicians	1,327	45.3
Draftsmen	1,362	45.8
Industrial engineering technicians and related specialists	537	47.5
Physical science technicians	441	48.3
Civil engineering and construction technicians and specialists	740	48.5
Technical writing and illustration specialists	222	38.3
Sales and service technicians	109	66.1

Among the employers who commented on their negative answer to the question, the majority simply expressed some version of the proposition that there was no substitute for experience. Others stressed that the work in question required familiarity with the particular company's products, equipment, processes, and production techniques, which could only be acquired by experience within that company; that the work was highly experimental or classified, and so could not be taught in the classroom; that the equipment used was too expensive to be maintained by a school; and, generally, that the work was too new, varied, changing, or complex to be left entirely to the schools.

VALUE OF POST-HIGH-SCHOOL EDUCATION

A young person looking forward to work in a technical occupation might well ask, why bother to pursue schooling beyond high school if employers on the average equate 1.5 or 2 years of work experience with post-high-school education. By choosing work experience he may not only be earning an income but may save the expense of going to school.

In weighing the pros and cons, he should not overlook such considerations. They have a place on the scale. But he would also be ill-advised to disregard the considerations on the other side of the scale:

(1) There is no assurance that he will find a job that will give him the kind of experience employers will equate with post-high-school education. To count, work experience usually (though not always) must be related to the sort of technical work that he hopes to get into. On the other hand, he can be pretty sure of gaining employer recognition of any reputable program of post-high-school technical education.

(2) His chances of promotion up the technical occupation ladder are better if he has had post-high-school education. The more advanced and higher-grade levels of technical occupations tend to require more formal post-high-school education (even though experience is important, too, and in some occupations more important as a qualification for promotion than formal education is).

(3) The high-school-only requirement may be deceptive, since the employer may require that candidates for a technical job pass a qualifying test. Moreover, employers' "high school" requirement frequently involves a pretty good knowledge of science and/or mathematics, which might be obtained outside of school but is most easily obtained in school.

(4) Many employers will accept persons who have not gone beyond high school but will prefer persons who have. In a situation where there are more applicants than jobs, the person with post-high-school education has a better chance of getting the job, other things being equal. The majority of workers in technical occupations have had some post-high-school education.

(5) Finally, a broad education in science, mathematics, and other basics is less likely to be made obsolete by technological developments than work experience backed up only by a high-school education. Narrowly-trained individuals are at the mercy of circumstances. Both persons who have had college or technical-institute training and those who have not may well help protect their future in technical jobs by taking advanced post-high-school course work.

VALUE OF HIGH-SCHOOL TECHNICAL CURRICULUMS

To some extent the advantages that technical workers draw from post-high-school education are shared by graduates of high-school technical programs. A number of public high schools offer courses in the subject matter with which technicians and technical specialists are concerned, and the returns of the survey suggest that employers think well of these programs.

The curriculums of the high-school technical programs include aeronautics, architectural drafting and building construction, structural drafting and design, electricity-electronics, industrial chemistry, instrumentation, mechanical design and construction, computer technology, advertising and industrial design, and fashion design.

Outstanding among the public schools offering technical programs are Brooklyn Technical High School (Brooklyn) and Hutchinson-Central Technical High School (Buffalo). Education in technician subjects also was given, in 1962, by vocational high schools in a number of communities, including Schenectady, Rochester, Syracuse, Binghamton, Utica, Rome, Niagara Falls, Poughkeepsie, Elmira, Endicott, Jamestown, Yonkers, Floral Park, East Meadow, Batavia, Hornell, Levittown, Merrick, Olean, and Selden-Centereach, and also by the Nassau County Vocational Education and Extension Board, and the Boards of Cooperative Educational Services in Suffolk, Rockland, Westchester, and Erie Counties.

Graduation from a vocational-technical or vocational-industrial high-school program was required by employers for about 8 percent of the workers in technical occupations covered by the survey. For about 5 percent of the workers graduation from a technical high school or from a technical program in a high school was specified; half of these workers were employed in New York City and Buffalo.

Both the 8 percent and the 5 percent figures probably are understated, because employers were not always knowledgeable about the distinctions between high-school programs and, in the field interviews, were not pressed to make a distinction where they did not volunteer one.

Employers reported that they required substantially less work experience of graduates of technical programs than they did of other high-school programs.

Education program	*Years of work experience required*
High school, total	3.4
Technical and vocational programs	2.6
Technical programs only	2.2
Other high school	3.6
Post-high-school, total	1.9
Technical-institute graduates	1.4
Technical-institute nongraduates	2.2

As may be seen from these figures, high-school technical-program graduates compare favorably with workers from post-high-school programs so far as years of work experience required by employers are concerned.

TESTS AND LICENSES

Employers were asked to report in the case of each technical occupation whether a license, certification, or accreditation of some kind, or successful completion of a formal test was required as a condition of employment. The classifications below were used.

Government license or permit

A government-agency license, permit, or certificate is required to practice a number of technical occupations. The principal licenses are the following:

Licenses issued by the New York State Department of Education are required for dental hygienists and physical therapists.[1] Under a grandfather clause, persons who do not qualify for a license but who were employed as physical therapists two years prior to 1950 may obtain a permit from the Education Department that allows them to administer physical therapy under the supervision of a licensed physical therapist or physician. The dental hygienists and physical therapists account for almost all of the licenses required of biological, medical, dental, and related science technicians and specialists.

An airway tower specialist is required to have an air traffic control specialist certificate issued by the Federal Aviation Agency (FAA). In addition, he must have a facility certificate or rating from the FAA to show that he is familiar with the particular location and is qualified to work there.

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[1] A few employers require their physical therapists to be registered by the American Registry of Physical Therapists, in addition to holding a State license.

A flight dispatcher needs an FAA dispatcher certificate.

An air carrier inspector and a general aviation inspector need an airman certificate issued by the FAA. Some persons requiring such licenses—mostly government employees—are classified in the safety and sanitation inspector group, while others, employed by airlines to troubleshoot aircraft, are in the electro and mechanical engineering technician group.

The Federal Communications Commission (FCC) requires any person who operates or adjusts broadcast transmitters to hold a Radiotelephone First Class Operator License. The government licenses required of the broadcasting, motion picture, and recording studio specialists are of this type. Some stations prefer to have as many persons as possible legally qualified to operate the transmitter, in case an emergency arises, and therefore may require licensing not only for transmitter technicians but also for other types of broadcast technician.

Persons who test milk and cream (bacterial counts, Babcock and Gerber tests, etc.) must have certificates from the New York State Department of Agriculture and Markets. Technicians requiring such certification are in the physical science, product testing, and safety and sanitation inspector categories.

Other types of government certificates required for safety and sanitation inspectors include a certificate of fitness for blasting inspectors and boiler inspectors, a fire-training certificate for safety field representatives (fire), etc.

A government license for inspecting and grading farm products is issued by the United States and New York State Agriculture Departments.

Professional land surveyors, architects, and engineers must be licensed by the New York State Education Department. Land surveying licenses are required of some surveying technicians in the civil engineering category. A few employers require their draftsmen and/or designers to be licensed architects and certain electro and mechanical engineering technicians to be licensed engineers.

Professional accreditation

The cases in which registration or accreditation by a professional society is a condition of employment are all found in the medical field. They include:

Medical technologists MT (ASCP) are certificated by the Registry of Medical Technologists of the American Society of Clinical Pathologists.

X-ray technicians RT (ARXT) are registered by the American Registry of X-ray Technicians.

Inhalation therapists are registered by the American Registry of Inhalation Therapists.

Occupational therapists (OTR) are registered by the American Occupational Therapy Association.

Physical therapists are registered by the American Registry of Physical Therapists.

Medical record librarians (RRL) are registered by the American Association of Medical Record Librarians.

Medical record technicians (ART) are accredited by the American Association of Medical Record Librarians.

Many employers in the medical service field prefer that their workers have accreditation but do not require it. These are not included in the count.

In addition to the above, some employers prefer engineering technicians certificated by the Institute for the Certification of Engineering Technicians or who have completed engineering technology curriculums accredited by the Engineers' Council for Professional Development.

Civil Service examinations

This category refers largely to formal written examinations. Not included are "unassembled examinations" and other methods of rating based on evaluation of experience and education.

Formal company tests

These include mainly formal tests of achievement, aptitude, and personality. Some are tests prepared by the company. Some are standard tests to measure intelligence (Wonderlic Personnel Test, S.R.A. Nonverbal Form, Otis Self-Administering Tests of Mental Ability, Wesman Personnel Classification Test, etc.), personality (Beinreuter Personality Inventory, Guilford-Zimmerman Temperament Survey, Thematic Apperception Test, Rorschach, etc.), achievement (California Basic Skills Test, etc.), mechanical aptitudes (Bennett Test of Mechanical Comprehension, Industrial Training Classification Test, etc.), vocational interests (Kuder Preference Record, Minnesota Engineering Analogies Test, etc.), and vocational skills (Programmers Aptitude Test—PAT—by the Psychological Corporation, Purdue Industrial Mathematics Test, etc.). Some employers have prospective employees tested by General Aptitude Test Battery (GATB), given by the New York State Employment Service. Some who require no formal tests ask job applicants to submit a sample of their work.

Of the total of 148,684 workers in technical occupations, approximately one-fourth were employed in jobs for which some kind of license or test was required:

Type of test or license required	*Number*	*Percent*
Total	148,684	100.0
No test or license	110,542	74.5
Government license or permit[a]	7,494	5.0
Professional society accreditation	933	0.6
Civil Service examination	12,254	8.2
Company formal test	17,461	11.7

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[a] Cases where there was a requirement in addition to a government license or permit are found only under this heading.

Corresponding figures for each of the technical occupation groups will be found in table 45 in supplement A to volume 1. The chapters of volume 2 dealing with the various specific technical occupations contain further comment on the use of licenses and tests.

SUBJECT-MATTER KNOWLEDGE AND TECHNICAL SKILLS

Among the questions included in the survey interviews with employers was one concerning what subject-matter knowledge and technical skills are needed to perform the various technical jobs. The replies are presented in detail, separately for each technical occupation group, in volume 2 of this report. The present section gives a summary of the findings.

A substantial element of interpretation has gone into the presentation of the data on subject knowledge needed—made necessary by the incompleteness of employer response on this point. In some cases the persons interviewed were personnel officials who were unable to supply information on subject-matter needs in detail. In other cases the company officials interviewed were unwilling to take the time required to go into the question thoroughly. And, apart from incompleteness, there was some inconsistency among employers in reporting, especially in the extent to which they specified subject-knowledge needs in detail.

The result of this lack of completeness and uniformity in reporting is that figures on numbers of employers reporting any particular subject could not always be taken at face value. But they did make it possible to group subject-knowledge needs into three categories:

A. "Generally needed"—a category that includes subjects needed in the performance of most if not all jobs falling under the occupation in question.

B. "Needed in a substantial proportion of cases"—which includes subject knowledge that is often needed, though by no means universally or even in a majority of jobs falling under the occupation in question.

C. "Needed occasionally"—which includes subject knowledge that is needed only in a scattering of jobs, but often enough to be considered more than a rare occurrence.

Subjects under *B* and *C* are likely to be required in higher grades of a job, or in work on special kinds of equipment, products, or processes.[1]

Note that a need for knowledge of a subject does not necessarily mean that a classroom course of instruction in that subject is required. Knowledge adequate to perform a job may in some instances be obtained through work experience or as part of a course in a broader subject.

There are 72 technical occupations for which the information on subject-knowledge needs has been classified in this way; they take in 125,400 workers. In 58 of them general physics[2] is needed (whether in the *A*, the *B*, or the *C* classification). General chemistry[2] is also on this high level. Trigonometry (math through trigonometry) is a close third. Technical drawing is next.[3] The following table shows the top subjects in the order of the number of occupations for which they are said to be needed; the "worker" figure is the number of technicians and/or specialists employed in those occupations:

Subject	*Occupations*	*Workers*
Physics, general	58	101,300
Chemistry, general	57	110,700
Trigonometry	54	96,000
Technical drawing	43	88,100
Algebra, advanced	35	73,300
Electricity, basic	33	68,700
Calculus	27	51,000
Mechanics and strength of materials	24	65,300
Electronics, basic	23	55,100
Metallurgy	22	47,500

The next table shows the extent to which classification *A* ("generally needed") was applied to these same subjects:

Subject	*Occupations*	*Workers*
Physics, general	42	83,200
Chemistry, general	12	35,300
Trigonometry	29	70,100
Technical drawing	25	45,600
Algebra, advanced	7	11,500
Electricity, basic	8	24,000
Calculus	1	800
Mechanics and strength of materials	4	18,400
Electronics, basic	6	24,800
Metallurgy	1	1,000

This table shows that the subjects most often reported as "generally needed" are general physics, mathematics through trigonometry, and technical drawing. Next in importance in this classification are general chemistry, basic electricity, basic electronics, advanced algebra, and (as table DD shows) instrumentation.

Table DD gives the "occupations" and "workers" count separately for each of these three classifications. It gives these counts for every subject matter reported for as many as three occupations.

Table EE relates, for each occupation group, the subject-matter knowledge that is "generally needed" to educational and experience requirements, and presents examples of related work experience that employers reported as helpful in acquiring requisite subject-matter knowledge and related technical skills.

Technical skills. Technical skills needed to perform the various technical jobs (as well as subject-matter knowledge needed) are listed in the appropriate chapters of volume 2 of this report. Most frequently mentioned by employers were the ability to use the following kinds of equipment and reference material:

. . Blueprints and schematics.

. . Technical manuals and handbooks.

. . Laboratory glassware and equipment, such as test tubes, beakers, flasks, pipettes, burettes, wash bottles, funnels, graduates, evaporating dishes, filters, crucibles, siphons.

. . Hand and power tools, such as hammers, wrenches, pliers, files, shears, screwdrivers, drills, lathes, grinders, soldering irons.

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[1] The subject-matter grouping presented in this report was done by or reviewed by persons who are members of the technical-education profession. (The preface to this volume gives names of persons who participated in preparing volume 2 of the report.)

[2] The "general physics" and "general chemistry" courses referred to in lettering, use of instruments, geometric constructions, orthographic projections, dimensioning, conventional practices, auxiliary views, pictorial representations, fastening devices, working drawings, assembly drawings, and technical graphs and charts. It may occasionally include such specialized topics as developments, gears and cams, structural drafting practices, electrical drafting, and nomography.

[3] Technical drawing, as referred to in this report, generally includes this report are introductory courses that present elementary principles. No distinction has been made here between introductory courses at high-school and college level.

. . Drafting instruments and equipment, such as drawing board and drafting table, T-square, drafting machine, parallel straight edge, triangle, protractor, architect and engineer scales, French curve, compass, divider, lettering pens and lettering sets and guides, drafting templates.

. . Mechanical precision measuring instruments, such as micrometers, vernier calipers, gauges, comparators.

. . Slide rules and desk calculators.

. . Electrical and electronic instruments and equipment, such as voltmeters, ammeters, wattmeters, ohmmeters, Wheatstone bridges, impedance bridges, oscilloscopes.

. . Specialized equipment, such as colorimeters, spectrophotometers, densitometers, microscopes, hardness testers, X-ray machines.

Table DD. Subject-Matter Knowledge Needs Reported by Employers for Technical Occupations

Subject matter	Total		A. Subject generally needed		B. Subject needed in substantial number of cases		C. Subject occasionally needed	
	Occupations[a]	Workers[b]	Occupations[a]	Workers[b]	Occupations[a]	Workers[b]	Occupations[a]	Workers[b]
Physics, general	58	101,300	42	83,200	5	6,000	11	12,100
Chemistry, general	57	110,700	12	35,300	26	51,600	19	23,800
Trigonometry (mathematics through trigonometry)	54	96,000	29	70,100	15	15,000	10	10,900
Technical drawing	43	88,100	25	45,600	10	12,200	8	30,300
Algebra, advanced	35	73,300	7	11,500	13	24,800	15	37,000
Electricity, basic	33	68,700	8	24,000	13	23,300	12	21,400
Calculus	27	50,900	1	800	11	11,900	15	38,200
Mechanics and strength of materials	24	63,300	4	18,400	11	27,400	9	17,500
Electronics, basic	23	55,100	6	24,800	10	17,600	7	12,700
Metallurgy	22	47,500	1	1,000	11	24,500	10	22,000
Machine shop theory and practice	21	56,300	3	8,500	11	22,000	7	25,800
Electrical technology, orientation	18	35,000	1	12,900	5	3,700	12	18,400
Hydraulics	18	40,400	—	—	7	15,100	11	25,300
Construction technology, orientation	16	25,100	4	3,400	11	21,100	1	600
Geometry, solid	14	15,200	—	—	2	200	12	15,000
Manufacturing processes	13	25,000	—	—	9	12,000	4	13,000
Instrumentation	13	39,400	8	32,400	2	1,500	3	5,500
Geometry, analytic	13	26,000	—	—	6	3,100	7	22,900
Mechanical technology, orientation	11	15,500	2	1,300	6	13,300	3	900
Biology, general	10	24,300	4	11,700	2	4,900	4	7,700
Building codes	9	8,100	3	3,100	3	1,200	3	3,800
Heating, ventilating, air conditioning, refrigeration, sanitation, and related codes	9	10,100	2	500	1	300	6	9,300
Quantitative and qualitative analysis	9	20,200	3	14,200	3	2,500	3	3,500
Computer technology	8	27,200	—	—	—	—	8	27,200
Bacteriology	7	20,400	3	12,700	2	2,100	2	5,600
Surveying	7	8,600	2	2,200	2	1,600	3	4,800
Chemical technology	6	8,300	1	500	1	400	4	7,400
Chemistry, organic	6	17,300	2	4,300	2	11,500	2	1,500
Electrical codes	6	1,700	1	500	3	600	2	600
Pneumatics	6	22,500	—	—	3	14,000	3	8,500
Thermodynamics	6	3,900	—	—	2	700	4	3,200
Statistics	6	4,700	1	1,300	1	1,100	4	2,300
Acoustics	5	14,800	—	—	2	500	3	14,300
Chemistry, inorganic	5	16,900	1	9,900	2	1,400	2	5,600
Civil technology, orientation	5	6,600	1	100	—	—	4	6,500
Concrete and steel	5	4,300	2	2,700	1	100	2	1,500
Machine design	5	12,700	2	6,200	—	—	3	6,500
Optics	5	17,900	—	—	—	—	5	17,900
Physics, advanced	5	11,800	—	—	2	5,900	3	5,900
X-ray technology	5	8,700	1	3,300	3	5,300	1	100
Physiology	4	4,700	2	3,400	2	1,300	—	—
Geology	4	3,000	—	—	1	600	3	2,400
Chemistry, physical	4	5,800	—	—	—	—	4	5,800
Chemistry, polymer	4	6,200	—	—	1	500	3	5,700
Descriptive geometry	4	15,800	—	—	—	—	4	15,800
Differential equations	4	7,900	—	—	—	—	4	7,900
Architectural technology, orientation	3	4,100	1	300	1	3,500	1	300
Chemistry, industrial	3	4,800	—	—	1	300	2	4,500
Electrical machinery	3	8,800	—	—	3	8,800	—	—
Electro-mechanical technology, orientation	3	5,800	—	—	1	800	2	5,000
Electronics, advanced	3	11,000	—	—	3	11,000	—	—
Engineering mathematics	3	4,400	—	—	1	1,000	2	3,400
Mechanisms	3	14,000	—	—	3	14,000	—	—

[a] Number of occupations for which the subject was reported to be needed.

[b] Number of persons in the occupations referred to in footnote *a*.

NOTE: Excluded are subjects relating to occupations in broadcasting, airway tower, and data-processing groups. Also excluded are those subjects that were needed by technicians, in two occupations or less. See various chapters in volume 2 for further details.

Table EE. Education and Training Requirements, Subject-Knowledge Needs, and Related Work Experience in Technical Occupations

Technical occupation	Technicians and technical specialists		Median years of experience required	Subjects reported as generally needed	Examples of types of related work experience (exclusive of experience in same field of work)
	Number	Percent working for employers who require post-high-school education			
MATHEMATICS TECHNICIANS (83.8% work for employers who prefer post-high-school education)	831	81.2	1.5	Trigonometry; calculus; general physics; orientation in mechanical technology.	Engineering technician, statistical clerk, or other job in which nonprofessional training or experience is obtained in the application of mathematical techniques.
TECHNICAL WRITING AND ILLUSTRATION SPECIALISTS (85.7% work for employers who prefer post-high-school education)	3,034	64.9	3.2		*Writer*—experience that provides an opportunity to obtain an understanding of the basic concepts and practices in the subject-matter field; its vocabulary; how to acquire additional information concerning the field; work with equipment, products, or devices requiring understanding of their principles and operations and the ability to describe them in clear language; etc. *Illustrator*—commercial artist or illustrator in the fields of public information, exhibits, advertising, publishing, etc.; other experience involving graphic presentation of objects, facts, or ideas.
Technical writers and editors	1,669	84.5	2.9	Subject-matter knowledge in field of specialty.	
Technical illustrators	1,082	44.5	3.9	Technical drawing.	
Specification writers other than construction	237	21.9	2.3	Subject-matter knowledge in field of specialty.	
PHYSICAL SCIENCE TECHNICIANS (79.7% work for employers who prefer post-high-school education)	8,969	62.1	2.3		Tester, inspector, physical science aid, laboratory aid, or other job in which knowledge is obtained on how to observe and record data, use scientific instruments in measuring physical phenomena, make computations involving the use of high-school mathematics, etc.
Physics, radiation, and nuclear	761	78.6	1.9	Advanced algebra; general chemistry; general physics; technical drawing.	
Industrial and other chemicals	3,983	67.7	2.1	General chemistry; general physics; organic chemistry; quantitative and qualitative analysis.	
Physics-chemical	1,638	61.1	1.8	General chemistry; general physics.	
Beverages and other food products	478	59.0	0.0	General chemistry; general physics; general biology; bacteriology; orientation in chemical technology.	
Metallurgical and related	987	57.5	2.6	General chemistry; metallurgy; general physics.	
Pharmaceuticals	363	50.7	2.9	General chemistry; general physics; organic chemistry; quantitative and qualitative analysis; instrumentation.	
Fuels	338	32.5	3.6	General chemistry.	
Meteorology	185	31.9	3.9	Trigonometry; general physics; meteorology.	
Minerals and soil (mostly in government employment)	140	29.3	3.5	Trigonometry; advanced algebra; general physics; technical drawing.	

Technical occupation	Technicians and technical specialists		Median years of experience required	Subjects reported as generally needed	Examples of types of related work experience (exclusive of experience in same field of work)
	Number	Percent working for employers who require post-high-school education			
STRUCTURAL DESIGN TECHNICIANS AND SPECIALISTS (90.8% work for employers who prefer post-high-school education)	2,516	56.4	5.7		Draftsman; electrical and mechanical equipment design; craftsman in the building trades.
Architectural	349	70.8	5.0	Trigonometry; general physics; technical drawing; orientation in construction technology; orientation in architectural technology.	
Highway, street, and related construction n.e.c.	76	63.2	5.5	Trigonometry; general physics; technical drawing; orientation in civil technology.	
Structural	337	49.6	6.3	Trigonometry; general physics; technical drawing; orientation in construction technology.	
Mechanical	467	38.3	6.0	Trigonometry; general physics; technical drawing; heating, ventilating, air conditioning, refrigeration, sanitation; orientation in mechanical technology.	
Electrical	186	36.0	6.5	Trigonometry; general physics; technical drawing; basic electricity.	
ELECTRO AND MECHANICAL ENGINEERING TECHNICIANS (76.9% work for employers who prefer post-high-school education)	42,031	56.2	3.8		Nonprofessional technical work in an allied field (engineering aid, mathematics and production specialist, equipment specialist, draftsman, structural designer, laboratory mechanic, product inspector, etc.); journeyman in a related field requiring the construction, assembly, installation, production, maintenance, or repair of engineering systems or equipment; etc.
Electronic design	489	91.0	4.3	Trigonometry; advanced algebra; general physics; technical drawing; basic electronics.	
Electro-mechanical development	2,474	79.7	3.2	Trigonometry; general physics; technical drawing; basic electricity; basic electronics; instrumentation; mechanics and strength of materials.	
Electrical design	1,006	69.8	5.4	Trigonometry; advanced algebra; general physics; technical drawing; basic electricity.	For *design* and *development*, experience may be gained as a draftsman; tool and die maker; instrument or model maker; on production jobs such as wireman, assembler, etc.
Electronic development	4,873	69.1	2.7	Trigonometry; advanced algebra; general physics; technical drawing; basic electronics; instrumentation.	
Mechanical troubleshooting and related	1,919	65.1	3.4	Trigonometry; general physics; machine shop theory and practice.	For *troubleshooting*, experience may be gained as a radio and TV repairman; teletypewriter repairman; maintenance mechanic; pipe fitter; electrician; machinist; inspector; tester; on production jobs such as assembler, solderer, wireman, etc.
Electrical development	2,497	64.6	3.4	Trigonometry; advanced algebra; general physics; basic electricity; technical drawing; instrumentation.	
Electro-mechanical design	1,744	61.5	6.1	Trigonometry; advanced algebra; general physics; technical drawing; basic electricity; basic electronics; mechanics and strength of materials; instrumentation; machine design.	

Table EE. Education and Training Requirements, Subject-Knowledge Needs, and Related Work Experience in Technical Occupations (*continued*)

Technical occupation	Technicians and technical specialists		Median years of experience required	Subjects reported as generally needed	Examples of types of related work experience (exclusive of experience in same field of work)
	Number	Percent working for employers who require post-high-school education			
Mechanical design	4,450	56.5	4.9	Trigonometry; general physics; technical drawing; machine shop theory and practice; mechanics and strength of materials; machine design.	
Electronic troubleshooting and related	5,429	54.2	3.4	Trigonometry; general physics; basic electronics; instrumentation.	
Electro-mechanical troubleshooting and related	9,767	53.8	3.5	Trigonometry; general physics; mechanics and strength of materials; basic electricity; basic electronics; instrumentation.	
Mechanical development	2,092	51.5	3.8	Trigonometry; general physics; technical drawing; machine shop theory and practice.	
Electrical troubleshooting and related	5,291	26.7	4.1	Trigonometry; general physics; basic electricity; instrumentation.	
SALES AND SERVICE TECHNICIANS (87.9% work for employers who prefer post-high-school education)	1,932	53.8	3.4	Trigonometry; general physics; subject matter knowledge in field of specialty.	Troubleshooter, craftsman, foreman, production worker, salesman, etc.
BIOLOGICAL, MEDICAL, DENTAL, AND RELATED SCIENCE TECHNICIANS (64.6% work for employers who prefer post-high-school education)	25,445	51.7	0.0		*Biological and medical laboratory and X-ray and related equipment technicians*—experience is usually within same field of work.
Dental hygienists	1,874	100.0	0.0	Oral anatomy; bacteriology; general chemistry; dental science; histology; pathology; nutrition; oral hygiene; pharmacology.	
Occupational, recreational, and other therapists	880	92.4	0.9	Anatomy; creative arts; health sciences; neurology; occupational skills; occupational therapy.	
Physical therapists	1,003	88.2	0.0	Anatomy; general biology; neurology; physiology; psychology; general physics; basic electricity; physical therapy.	
X-ray and related equipment technicians	3,013	61.0	1.2	Elementary anatomy; physiology; general physics; X-ray technology.	
Biological and medical laboratory	9,898	59.7	1.6	General biology; bacteriology; general chemistry; inorganic chemistry; quantitative and qualitative analysis; medical laboratory technology.	

Technical occupation	Technicians and technical specialists		Median years of experience required	Subjects reported as generally needed	Examples of types of related work experience (exclusive of experience in same field of work)
	Number	Percent working for employers who require post-high-school education			
General medical assistants, doctor's office (excluding nurses and secretaries)	1,114	46.5	0.0	Medical office procedures and practices; medical secretarial duties.	
Medical record librarians	347	42.4	2.7	Anatomy; general biology; physiology; medical jurisprudence; medical record science and procedures.	*Medical record librarian*—coding and indexing of diseases, professional evaluation of medical records, compiling hospital statistics, maintaining medical record filing systems, etc.
Electroencephalograph	159	29.6	1.1	Anatomy of the brain; electroencephalograph technology.	*Electroencephalograph*—nurse's aid, nurse attendant, laboratory technician or assistant, medical corpsman, worker on technical processes related to the manufacture and maintenance of electroencephalograph equipment, etc.
Inhalation therapy	153	19.0	0.9	Inhalation therapy technology.	
Electrocardiograph	548	16.2	0.9	Anatomy of the heart; electrocardiograph technology.	*Electrocardiograph*—experience similar to that for electroencephalograph technician.
Dental laboratory technicians	2,844	14.3	2.3	Oral anatomy; dental laboratory technology.	*Dental laboratory technician*—general experience in a dental laboratory; dental assistant; etc.
Dental assistants	2,331	9.3	0.0	Dental assisting; bookkeeping; typing.	
INDUSTRIAL ENGINEERING TECHNICIANS AND RELATED SPECIALISTS (59.0% work for employers who prefer post-high-school education)	6,901	45.0	3.9		Journeyman in a manufacturing craft, foreman; work related to production engineering, statistical or cost records maintenance, inventory control, purchase or supply operation, drafting, laboratory or production testing and inspection.
Production planners	993	53.3	5.7	General physics; manufacturing processes.	
Time and study men and standard setters	1,104	49.2	2.3	Time and motion study.	
Industrial process methods men	825	47.5	4.2	General physics; manufacturing processes.	
Production schedulers, coordinators, and expediters	515	46.6	3.9	General physics; manufacturing processes.	
Quality control and reliability technicians (About a third are Federal employees—See p. 46)	1,279	40.3	4.7	Trigonometry; general physics; manufacturing processes; statistics.	
Production cost estimators	395	36.7	3.6	General physics.	

Table EE. Education and Training Requirements, Subject-Knowledge Needs, and Related Work Experience in Technical Occupations (*continued*)

Technical occupation	Technicians and technical specialists		Median years of experience required	Subjects reported as generally needed	Examples of types of related work experience (exclusive of experience in same field of work)
	Number	Percent working for employers who require post-high-school education			
DRAFTSMEN (65.3% work for employers who prefer post-high-school education)	20,972	40.0	2.2		Jobs such as machinist, tool and die maker, sheet metal shop mechanic, template maker, pipe fitter, millwright, maintenance foreman, surveyor helper, wireman, assembler, drawing control clerk, copier, tracer, inker, blueprint-machine operator.
Architectural	3,508	56.4	2.5	Trigonometry; general physics; technical drawing.	
Electro-mechanical: construction	211	46.0	2.9	Trigonometry; general physics; technical drawing.	
Electrical-electronic: construction	684	44.3	1.7	Trigonometry; general physics; technical drawing.	
Structural	1,955	34.0	1.4	Trigonometry; general physics; technical drawing.	
Map, topographical, and geological	592	32.8	2.5	Trigonometry; general physics; technical drawing.	
Mechanical: construction	1,020	22.4	0.0	Trigonometry; general physics; technical drawing.	
CIVIL ENGINEERING AND CONSTRUCTION TECHNICIANS AND SPECIALISTS (44.3% work for employers who prefer post-high-school education)	13,464	27.2	4.5		Draftsman, construction trades craftsman, electrical and mechanical maintenance worker, construction trades foreman, lower-grade technical job in the construction field, etc.
Heating, air conditioning, and related equipment inspectors	54	44.4	6.5	Heating, ventilating, air conditioning, and refrigeration and related codes.	*Heating, air conditioning, and related equipment construction inspector*—installation of heating, ventilation, air conditioning, or refrigeration systems; maintenance mechanic; maintenance electrician.
Building construction technicians	1,765	38.2	6.4	Trigonometry; general physics; technical drawing; building codes; concrete and steel; orientation in construction technology.	*Building, civil engineering and construction technician*—contractor, construction trades craftsman or foreman, or other experience on construction projects involving responsibility for planning operations, timing and scheduling of work, maintaining specified standards of materials and workmanship, interpreting specifications, observing safety rules, etc.
Surveyors	1,171	38.1	4.8	Trigonometry; technical drawing; surveying.	*Surveyor*—rodman; instrumentman; cartographic aid; forestry aid; map draftsman or other experience affording an opportunity to acquire knowledge of the principles, techniques, and methods of surveying.

Technical occupation	Technicians and technical specialists		Median years of experience required	Subjects reported as generally needed	Examples of types of related work experience (exclusive of experience in same field of work)
	Number	Percent working for employers who require post-high-school education			
Highway, street, and other heavy construction technicians	983	29.5	10.2	Trigonometry; general physics; technical drawing; orientation in construction technology; concrete and steel.	*Building structure construction inspector*—journeyman in construction trades, rodman, instrumentman, surveying aid, construction draftsman, construction estimator, construction foreman, etc.
Instrument men	1,007	19.2	2.8	Surveying.	*Electrical and mechanical equipment construction inspector*—manufacture, installation, inspection, or testing of mechanical or electrical equipment in a factory, underwriter's testing laboratory, etc.; craftsman in a related field; etc.
Building structure inspectors	1,126	4.8	3.9	Building codes.	
Electrical and mechanical equipment construction inspectors	498	4.0	6.6	Electrical codes.	
Plumbing construction inspectors	214	0.0	5.8	Building codes.	*Plumbing construction inspector*—journeyman, plumber, etc.
SAFETY AND SANITATION INSPECTORS AND RELATED SPECIALISTS (29.6% work for employers who prefer post-high-school education)	4,084	14.6	4.6		
Sanitation	1,771	23.3	3.9	General chemistry; principles of sanitation and public health; government laws and regulations on sanitation and public health.	*Sanitation*—testing and inspecting, laboratory work, etc.
Industrial safety and fire prevention	2,253	8.2	4.7	Accident investigation and reporting; safety principles and methods; safety equipment; fire prevention techniques; fire protective equipment and devices; laws and regulations governing safety and fire prevention and control; orientation in electrical technology.	*Industrial safety and fire prevention*—production work, mechanical experience, journeyman in a related field, etc.
Air safety (all are government employees)	60	0.0	8.4	Aviation regulations and procedures; aeronautical technology.	*Air safety*—aircraft maintenance work requiring a comprehensive knowledge of the techniques of maintaining and repairing aircraft, power plants, systems, and components.
PRODUCT TESTING AND INSPECTION SPECIALISTS (22.3% work for employers who prefer post-high-school education)	8,059	4.1	2.2		Assembly and other production jobs; production and laboratory inspecting at a semiskilled level.
Food and agricultural products	563	16.5	0.0	General chemistry.	
Industrial X-ray and related processes	308	17.5	2.1	X-ray technology.	
Chemical and other nonmetal products n.e.c.	1,925	5.1	1.1	General chemistry.	

VI. EMPLOYMENT OF ENGINEERS AND SCIENTISTS

As was indicated in chapter I, during the course of the survey employers were asked to report how many engineers and scientists they employed. Architects and mathematicians were included under this general heading.

Over-all, the survey found 142,732 engineers, architects, scientists, mathematicians, and teachers of engineering, science, and technology employed in New York State in 1962, divided as follows:

Engineers and architects	86,393	
Engineers		82,442
Architects		3,951
Scientists and mathematicians	21,123	
Scientists		19,321
Mathematicians		1,802
College teachers	17,865	
Engineering and architecture		2,834
Science and mathematics		12,228
Technology		2,803
High school teachers (licensed)	17,351	
Science		8,354
Mathematics		8,747
Technology		250

Note: These figures exclude medical and dental practitioners as such, high-school vocational and industrial arts teachers, and graduate students engaged in part-time research or teaching. Included among college teachers are teachers in private trade schools.

Their specific fields were not always indicated precisely; for one reason because so many engineers work in two or more fields. A related problem is that the engineer's job title is frequently a functional one (for example design engineer, or application engineer, or development engineer), and it was necessary to determine the appropriate field (electronics, etc.). Employers were asked to report in these cases according to the subject on which most time was spent. Also, the scope of fields probably was interpreted differently in some instances; for example, a small employer may have reported as "mechanical engineering" an activity that a larger employer would have designated "industrial engineering." Many employers wrote in, on the survey reporting form, special types of engineering or science not listed on it. How many of these there were and how they were classified is indicated in the footnotes to table 46 in supplement A to volume 1.

Table FF. Distribution of Engineers and Scientists According to Occupation

Occupation group	Number	Percent
All engineers, scientists, teachers	142,732	100.0
Engineers and architects	86,393	60.5
Engineers	82,442	57.7
Electrical and electronic	26,164	18.3
Mechanical	22,721	15.9
Civil and construction	16,022	11.2
Chemical	7,271	5.1
Industrial	5,443	3.8
All other	4,821	3.4
Architects	3,951	2.8
Scientists and mathematicians	21,123	14.8
Scientists	19,321	13.5
Chemists	9,791	6.9
Medical scientists	3,114	2.2
Physicists	2,763	1.9
Biological scientists	1,771	1.2
All other	1,882	1.3
Mathematicians	1,802	1.3
College teachers	17,865	12.5
Science and mathematics	12,228	8.5
Engineering and architecture	2,834	2.0
Technology	2,803	2.0
High-school teachers	17,351	12.2
Mathematics	8,747	6.1
Science	8,354	5.9
Technical and technical-related	250	0.2

In the tabulation, persons on college faculties who do some teaching were classified as college teachers

Table GG. Percent Distribution of Engineers and Scientists According to Industry Division

Industry division	Total	Engineers and architects	Scientists and mathematicians	College teachers	High-school teachers
All industries: Number	142,732	86,393	21,123	17,865	17,351
Percent distribution					
All industries: Percent	100.0	100.0	100.0	100.0	100.0
Manufacturing	38.2	50.2	52.7	—	—
Government	22.3	11.4	13.1	23.5	87.0
Private colleges and schools	11.6	[a]	3.6	76.0	13.0
Research laboratories and engineering services[b]	10.4	15.2	7.9	—	—
Construction	5.5	9.0	0.3	—	—
Transportation, communication, and public utilities	3.3	5.4	0.3	—	—
Private medical services	1.3	[a]	8.5	0.2[c]	—
All other	7.4	8.8	13.6	0.3[c]	—

[a] Less than 0.05 of a percent.
[b] Includes architectural as well as engineering services; research, development and testing laboratories; and business and management consulting services.
[c] These are teachers in schools that are a part of a hospital or a nonprofit research organization.

even though they were spending a major part of their time, when the survey was made, on research and development work.[1]

EMPLOYMENT

Electrical and electronic engineering leads all other occupations in terms of employment, accounting for 18 percent of all engineers, architects, scientists, mathematicians, and teachers. Next largest is mechanical engineering and then civil and construction engineering. Chemists, the largest group of scientists, constitute 7 percent of the total. (Table FF, based on table 46 in supplement A to volume 1.)

Manufacturing, government, private colleges and schools, and private research laboratories and engineering services are the largest employers of engineers and scientists. (Table GG, based on table 46.)

Area-wise, three-fifths of all employment of engineers and scientists in New York State is outside New York City. The heaviest concentrations outside the city are in Nassau and Suffolk counties and in the Buffalo area. (Table HH, based on table 47.)

Table HH. Percent Distribution of Engineering and Science Employment by Area

Area	Number	Percent
New York State	142,732	100.0
New York City	58,318	40.9
Nassau-Suffolk	18,158	12.7
Buffalo	13,576	9.5
Albany	8,398	5.9
Rochester	8,118	5.7
Syracuse	7,239	5.1
Westchester	5,593	3.9
Utica	2,766	1.9
Binghamton	2,552	1.8
All other	18,014	12.6

DEGREES HELD

Employers were asked to report the number of persons *working as* engineers or scientists, not the number having engineering or science degrees. It was the intention to *exclude* from this count persons *with degrees* who at the time of the survey were working at the subprofessional level as technicians, or in a nonengineering or nonscientific capacity as salesmen, managers, administrators, or officials of other sorts; and it was the intention to *include* persons *without degrees* who actually were working in the capacity of engineer, scientist, or the like. An obstacle to obtaining reports on a "working as" basis, rather than on a "degree" basis, was the fact that certain large employers do not maintain records of persons working as engineers. Instead they reported the number of persons who have engineering degrees, irrespective of whether they were doing engineering work and irrespective also of whether there were non-degree people who were working as engineers. Because of that practice, the data of the study are not uniformly on a "working as" basis. However, they are predominantly on that basis; even in those cases in which the firm reported employment on a degree basis, it usually was possible to exclude those persons with engineering degrees who were employed outside the engineering field, especially when they were employed at administrative and managerial work not directly related to engineering.

Persons working as engineers who do not have degrees are apt to be older people with substantial length of service in the company. A special tabulation prepared for the survey by a large, stable manufacturer of metal machinery and equipment in New York State, which employed about 300 persons on engineering work, disclosed that the median length of service with the company of those without engineering or other advanced degrees was 22 years. This compared with a median of about 10 years of service for engineers having degrees.

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[1] The figures probably understate the number of scientists and engineers employed on research and development work carried on in universities and hospitals under grants from government and from other organizations. Personnel office records in universities and hospitals in some instances were admittedly incomplete in this respect. On the other hand, some of this research and development is done by teachers on the regular staff of the organization, who are included in the count. And much of it is done on a part-time basis by outside practitioners such as physicians, so that the total number of full-time-equivalent workers is considerably lower than the number of different persons engaged in research and development. For colleges and universities in the nation as a whole, the National Science Foundation found that in 1961 the number of engineers and scientists in research and development, when figured on a full-time-equivalent basis, was about 80 percent of the total number of different engineers and scientists who did some research and development work.

Of the total of 142,732 engineers, scientists, and teachers of these subjects, including architects and mathematicians, 124,511, or 87.2 percent, were reported as having an engineering degree, architecture degree, or a bachelor-of-science or higher science degree. An additional 2,700 or so were reported as having a bachelor or higher degree not in engineering or science. Some 15,500, or 11 percent, were reported as having no four-year college or higher degree.

An occupation-by-occupation review of the percent with bachelor or higher degrees show civil and construction engineers to have a proportion below the average. In general, both college and high-school teachers had degrees; the over-all average of college teachers (93.7 percent) is as low as it is because the figure for teachers of technology (60.4 percent) is a component. This figure is explained by the large number of teachers of drafting, dental laboratory technology, and electronics in private trade schools who do not have degrees. See the by-occupation analysis in table I-I. The figures in parenthesis show the proportion of the total number in the occupation whose degree is in engineering, architecture, or science. (This table is derived from table 49 in supplement A to volume 1.)

Table I-I. Percent of Engineers and Scientists who Have Bachelor or Higher Degree, by Occupation

(In parenthesis: percent whose degree is in engineering, architecture, or science)

Occupation	Total number	Percent with degree
All engineers, scientists, teachers	142,732	89.1 (87.2)
Engineers and architects	86,393	84.2 (82.5)
Engineers	82,442	83.9 (82.2)
Electrical and electronic	26,164	85.4 (84.2)
Mechanical	22,721	82.6 (80.2)
Civil and construction	16,022	80.6 (79.8)
Chemical	7,271	94.7 (93.6)
Industrial	5,443	74.8 (69.8)
All other	4,821	87.7 (85.3)
Architects	3,951	90.1 (88.5)
Scientists and mathematicians	21,123	96.5 (94.4)
Scientists	19,321	96.7 (95.4)
Chemists	9,791	96.0 (93.9)
Medical scientists	3,114	99.5 (99.5)
Physicists	2,763	98.3 (97.8)
Biological scientists	1,771	96.4 (95.3)
All other	1,882	94.3 (92.7)
Mathematicians	1,802	94.3 (83.4)
College teachers	17,865	93.7 (89.7)
Science and mathematics	12,228	99.9 (96.5)
Engineering and architecture	2,834	99.5 (97.2)
Technology	2,803	60.4 (52.6)
High-school teachers (licensed)	17,351	100.0 (99.8)
Mathematics	8,747	100.0 (99.7)
Science	8,354	100.0 (99.8)
Technical and technical-related	250	100.0 (100.0)

FUNCTIONS

In reporting the number of engineers and scientists employed, employers were asked to separate (1) those engaged in engineering or science activities proper, that is, research design, development, labora-

Table JJ. Percent Distribution of Engineers and Scientists According to Function, by Occupation

Occupation	All functions	Research, design, development, laboratory, production, and related operations	Teaching, sales, and administration
All engineers, scientists, teachers	100.0	64.9	35.1
Engineers and architects	100.0	82.8	17.2
Engineers	100.0	82.7	17.3
Electrical and electronic	100.0	88.9	11.1
Mechanical	100.0	79.9	20.1
Civil and construction	100.0	85.6	14.4
Chemical	100.0	76.2	23.8
Industrial	100.0	82.4	17.6
All other	100.0	63.3	36.7
Architects	100.0	84.6	15.4
Scientists and mathematicians	100.0	87.3	12.7
Scientists	100.0	88.1	11.9
Chemists	100.0	85.2	14.8
Medical scientists	100.0	97.8	2.2
Physicists	100.0	91.0	9.0
Biological scientists	100.0	87.0	13.0
All other	100.0	83.8	16.2
Mathematicians	100.0	79.1	20.9
College teachers	100.0	14.7	85.3
Science and mathematics	100.0	17.8	82.2
Engineering and architecture	100.0	15.8	84.2
Technology	100.0	0.2	99.8
High-school teachers	100.0	[a]	100.0
Mathematics	100.0	—	100.0
Science	100.0	[a]	100.0
Technical and technical-related	100.0	—	100.0

[a] Less than 0.05 of a percent.

tory, production, and related operations; and (2) those engaged in teaching engineering and science subjects or engaged in sales or administrative work, though in an engineering or science capacity.

About two-thirds of the engineers and scientists were reported engaged in the first group of functions, one-third in the second. Excluding teachers as such, the first group of functions account for some 83 percent of the total. Table JJ (based on table 48) tells for each occupation what percent are engaged in the more usual functions; the others in the occupation are engaged in teaching, sales, or administration.

VII. EMPLOYER VIEWS AND POLICIES ON UTILIZATION AND EDUCATION OF TECHNICIANS

How far employers go in using technicians to assist and support professional engineering and scientific staff is one of the subjects of this chapter and is also the subject of chapter VIII.

Field interviewers asked employers to tell about their policies concerning how the engineering and scientific tasks performed by their firms were divided up between professionals and technicians. Their responses to these questions, together with their views concerning the education of technicians, are reported in this chapter. Chapter VIII measures the utilization of technicians and other workers in technical occupations in terms of how their numbers compare with the number of engineers and scientists employed.

This part of the survey covered employers in all industries except government and medical services. It was limited to establishments employing workers in technical occupations or engineers (and/or scientists) or both. There were about 6,350 establishments, with approximately 1,363,000 workers, in this category in the sample of the survey (see chapter I). Of these, 1,300 (20 percent) answered one or more of the questions on utilization and education. These respondents accounted for around half of the technical workers and of the engineers and scientists employed in the establishments included in the sample:

	Sample	*Respondents*	*Respondents as percent of sample*
Number of establishments	6,347	1,300	20
Number of their workers	1,362,706	735,166	54
Number in technical occupations	85,679	47,060	55
Number of engineers and/or scientists	81,999	37,754	46

UTILIZATION OF TECHNICIANS

The person interviewed on the question of utilization typically was either the personnel director or the head engineer, in larger establishments, and the proprietor or plant manager in smaller firms. These individuals were not equally interested or equally informed concerning the subjects raised, and as a consequence the answers in some instances were vague or general in nature and may not have reflected the best or most realistic thinking in the firm. However, the replies probably are indicative of main tendencies in policies and views.

(1) The first question asked was, *"What is the employer's thinking concerning the principal differences between the functions of technicians and those of engineers?"*

In the responses of the approximately 900 employers (establishments) who replied, the principal distinction pictures engineers and scientists as doing the original work of creating, initiating, planning, designing, and high-level problem solving, while the technicians carry out these ideas and plans. The other distinctions were theoretical versus practical work, complex versus less complex subject matter, wide range of subjects dealt with versus narrow range, and supervisory versus nonsupervisory responsibility. Very often the distinctions drawn by the employer were not clear-cut and rested on a difference of degree rather than a difference of kind.

The responses may be summarized as follows:

Number of employers reporting on duties and responsibilities of engineers and scientists	*923*
Create; initiate; design; engage in solving high-level, theoretical, and complex problems; evaluate and interpret data	603
Do over-all planning; see jobs through; direct; interpret; make decisions	191
Supervise technicians and other workers	166
Have over-all responsibility for projects	109
Have responsibilities that are greater, of a higher degree, cover a broader area or wider range, or are more complex than those of technicians	84
Develop methods and techniques; write new procedures, standards, and specifications	38
Other	19
Total (some employers reported more than one duty)	1,210

Number of employers reporting on duties and responsibilities of technicians	*814*
Assist and support; carry out engineers' designs, ideas, instructions, decisions, standards; do no original thinking; work on lower engineering level; organize, calculate, and present data	429
Do routine, physical, detailed, practical work, using tools, apparatus, and instruments	317
Are supervised and guided by engineers, scientists, or other	82
Work on limited phases of project or departmentalized activity	78
Other	51
Total (some employers reported more than one duty)	957

(2) The second question was, *"Are any engineers assigned to technician work because there is not an adequate supply of technicians?"*

Of the 1,075 employers responding, only 60 (6 percent) answered "Yes." Of the other employers, who replied in the negative, about 50 indicated that engineers were assigned to technicians' work, not because of a shortage of technicians, but because there was insufficient work for both engineers and technicians or in order to fully utilize the time of the engineers.

(3) The next question was, *"Are any technicians now doing work that formerly was performed by engineers?"*

Among the more than 1,100 employers who responded, the 21 percent who answered "Yes" mentioned design and development, drafting, and developing test procedures most often as the engineering functions to which technicians were assigned. If the history of assignments given to engineers and technicians in the reporting firms had been examined carefully in detail, very probably there would have been a significantly higher proportion of affirmative answers to the question.

Noteworthy among the reasons reported for the shift was that high-level technicians competent to perform significant engineering functions had become available to the employer for the first time.

The responses may be summarized as follows:

A. Technician work formerly performed by engineers

Number of employers reporting	*1,110*
Reported no technicians doing work formerly performed by engineers	878
Reported some technicians doing work formerly performed by engineers	232
Type of work	
Design and development	48
Drafting	30
Developing test procedures	23
Laboratory analysis (sciences)	19
Procurement and parts listing	18
Compilation and computation of data	13
Specification writing and editing	13
Building of equipment, breadboards, circuits, and prototypes	11
Estimating	10
Other	46
Total number of replies stating a specific type of work[a]	231

B. Reasons given for making shift

Number of employers reporting	*129*
Reasons	
Release engineers from routine work to devote time to creative, administrative, advanced engineering, and supervisory functions	33
Expansion of firm; increased volume of business	30
Availability for the first time of technicians competent enough to handle work performed by engineers	27
Shortage of engineers	15
Less expensive to use technicians	13
Other	23
Total number of reasons given[b]	141

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[a] Some employers made more than one reply, that is, named more than one specific type of work; on the other hand, 47 failed to specify a type.

[b] Some employers reported more than one.

(4) Employers were next asked, *"Are there functions now performed by engineers that could be broken out and assigned to technicians who meet the firm's technician qualifications? If yes, indicate which ones, and what problems, if any, would be involved in making this shift of responsibility."*

About a third of the employers who answered the question said "Yes." Various reasons were given why the shift of assignment had not in fact been made by those who said "No." Most frequent reason was lack of enough work for both engineers and technicians. The smallness of the establishment was mentioned in this connection. A shortage of qualified technicians and the burden of training technicians were reported in a significant number of cases.

Some employers preferred to handle technician work by assigning it to junior engineers in training. Some felt that technicians became frustrated if they were not promoted into engineering level work, which employers in these cases were reluctant to do. Some said they feared that if they used technicians to the maximum they would not have the capacity and flexibility to handle changing market conditions, especially new business.

A. Engineering functions that could be assigned to technicians

Number of employers reporting	*1,092*
No engineering functions could be assigned to technicians	760
Some could be assigned	332
Functions	
Drafting	58
Design; design modification	56
Test procedure development and evaluation	45
"Routine" scientific or engineering operations	43
Mathematical computations	17
Report writing; technical and procedure writing and editing	15
Laboratory analysis (sciences)	15
Estimating	14
Development; prototype building; mock-ups	13
Other	55
Total number of specific functions reported[a]	331

B. Problems in assigning engineering functions to technicians

Number of employers reporting	*332*
No problems	10
Problems	322
Type of problem	
Inefficient to have another technician on staff; not enough work to break out jobs or to spread between technician and engineer; firm too small.	100
Shortage of qualified technicians with ability to handle tasks; variety of chores to be done requires more qualified person than technician.	26
Problem of training technicians; volume of technician-level work does not warrant the time and effort to train.	22
Company wants professionals to handle all phases of job; uses technicians' jobs as training ground for engineers; professionals want to handle entire job—do not want to give up any part of it	16
Other	32
Total number of specific problems reported[b]	196

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[a] Some employers reported more than one function; 78 failed to specify a function.

[b] Some employers reported more than one problem; 134 failed to specify a problem.

(5) As to the future, employers were asked the question: *"Speaking of technician occupations generally, what important development or changes, if any, do you see coming in the future in the division of work between technicians, on the one hand, and engineers or scientists, on the other hand?"*

The half of the responding employers who thought there would be significant developments or changes in the future division of work between technicians and engineers and scientists were not very specific in indicating just what changes they saw coming, but the replies seem to add up to a picture of upgrading at both ends, with technicians taking over more complex engineering activities, freeing engineers to devote more time to advanced creative work, theoretical research, planning, and project direction.

The replies of the 819 responding establishments may be summarized as follows:

Number of employers reporting	*819*
No development or change	413
Development or change	406
Type of development or change	
Technicians will be upgraded; they will need a higher degree of knowledge and more engineering training	116
Technicians will take over routine engineering or scientific work and under guidance do experimentation	77
Technicians will do more designing	71
More technicians and more technician classifications will be needed	42
Technicians will have more duties; do a larger portion of work; and take over certain functions	42
Technicians will take over work of engineers so that engineers can devote more time to administrative and supervisory duties and do more theoretical research and special engineering work	21
There will be a narrowing of the gap between technicians and engineers leading to greater team work	18
There will be greater reliance on technicians, with further breakdowns of engineering jobs	13
Technicians will become more specialized	13
Technicians will need more individual and theoretical training because jobs will be more complex	12
Engineering work will become wider and more complex, and need higher endeavor leading to the upgrading of requirements and standards	59
Engineers' and scientists' work will be highly theoretical, including creative, advanced design work, over-all planning; engineers will be responsible for project from start to finish	27
Engineer will move toward pure research in science and development	20
More engineers will be needed	12
Other	42
Total number of specific types of change reported[a]	585

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[a] Some employers reported more than one type of development or change; 184 did not specify a type of change.

EDUCATION AND TRAINING OF TECHNICIANS

The remaining questions designed to elicit the views and policies of employers were directed at problems of technician education and training. Again it should be stressed that the individuals interviewed were not equally informed on the subject and that the replies in some instances were general in nature and may not have reflected any particular thought about or exposure to the problems raised. Again, however, it is felt that the replies probably indicate main trends of opinion, granting that the numbers lack precise significance.

(1) Employers were first asked, *"Do you recruit or obtain technicians from high schools or institutes?"* The intent of the question was to find out the extent of direct contact by employers with schools and technical institutes (including community colleges) for the purpose of recruiting or obtaining technicians.

A total of 1,201 employers responded; 514 (or 43 percent) said "Yes"; 687 (or 57 percent) said "No."

Even allowing for the fact that negative replies in some cases resulted from the absence of institutes or high schools giving technical courses in the area where the employer was located, the proportion of "No's" in the response is higher than one might have expected. The response confirms in a quantitative way the impressions of the field consultants who carried on the interviewing, that generally there was inadequate communication between the schools and institutes and industry. Many employers complained that they rarely if ever heard from schools (especially community colleges) concerning available technical manpower. Some were unaware that arrangements for special instruction of their employees could be worked out with the schools; some were even unaware of the existence of technical programs in the schools and community colleges. Others, on the other hand, felt that the schools were not keeping abreast of industry needs as well as they might.

These and other considerations entered into answers given by employers to the next question.

(2) Employers were asked, *"Could high schools and/or institutes do a better job of helping you meet your needs for technical jobs, either quantitatively or qualitatively?"*

Of 1,076 employers (establishments) responding, 471 (or 44 percent) thought the schools and institutes were doing a good job, and had no suggestions; 605 (or 56 percent) said they could do a better job.

Of the 605 employers who thought that a better job could be done, 396 indicated what sorts of things they had in mind. Their suggestions are listed below (some employers had more than one suggestion):

A. Suggestions relating to qualities or characteristics of students:

Emphasize good work habits; dependability; character training; ability to think; ability to write reports; verbal expression; honesty; taking pride in work; also emphasize English and generally a good basic educational background	101
Teach technical students to study, to want to get ahead	27
Train better-qualified and talented students; have higher standards of admittance	57

B. Suggestions relating to content of educational program:

Technical institutes should develop engineering and college-level courses enlarging the theoretical knowledge of technicians, so that they can take over engineering functions	25
Place more emphasis on technical courses and laboratory work	50
Place more emphasis on practical courses related to occupational specialties; use problems of industry; keep abreast of changing technology and area needs	45
High schools should teach two-year courses similar to those of technical institutes; introduce pre-engineering courses to qualified students; raise graduation standards	20
Update courses; textbooks; curriculums	14
Extend night-school programs; give correspondence courses; expand institute programs to 3 years	11

C. Suggestions relating to cooperation between schools and industry:

Bring about greater cooperation between schools and industry by giving guidance to students concerning needs and opportunities in industry and kinds of courses requested by industry. Sell technician field to students. At same time, industry should make its needs known to schools	65
Develop more cooperative school-work-experience programs	20

(3) The next question went further into the subject of the content of the educational program: *"In the training of technicians in the schools, what should be the relative emphasis on specialized work in technologies, on the one hand, and basic education in mathematics, science, engineering principles, and English and social studies, on the other hand?"*

A total of 953 employers responded to the question. They generally fell into one of three groups: those who said that emphasis should be on basic education; those who said that emphasis should be on technologies and specialization; those who said that there should be balance between the two or who qualified their preference.

A. Emphasis on basic education, total	*498*
"Emphasis should be on basic education"	342
Emphasis should be placed on English, mathematics, social studies, and communication skills	32
Emphasis on basic education should be over 75 percent	26
Emphasis on basic education should range from 50 to 75 percent	21
Basic education is first in importance, needed as a background for the technologies	22
Flexibility can only be achieved by good educational background	16
Specialization narrows student's chance to get ahead and is uneconomical to teach because need varies from industry to industry	15
Basic education should be emphasized where industry carries on in-plant training	14
Basic, with technical subjects limited to field chosen by students	10

B. Emphasis on specialization in technologies, total	*261*
"Emphasis should be on specialization in technologies"	198
Institutes should emphasize specialization	31
Emphasis on technologies should range from 50 to 75 percent	15
Emphasis on technologies should be over 75 percent	6
No basic education should be given except what is required to perform job	11

C. Balanced education and qualified preferences, total	*194*
"Balance between basic education and specialization in technologies"	149
Greater correlation or integration of basic education and specialization	17
Specialization for some; broad education for others, depending on occupation	13
Other	15

More employers emphasized basic education than specialization. But there is a significant difference between the replies of small and large employers in this respect. Relatively more small employers emphasized specialization. But there was a significant difference be- large employers emphasized basic education:

Size of establishment	*All establishments reporting*	*Emphasize basic education*	*Emphasize technologies*	*Emphasize balance between them*
		Number of establishments		
All sizes	953	498	261	194
1- 99 employees	346	162	111	73
100-999 employees	494	266	125	103
1,000 and over	113	70	25	18
		Percent distribution		
All sizes	100.0	52.2	27.4	20.4
1- 99 employees	100.0	46.8	32.1	21.1
100-999 employees	100.0	53.8	25.3	20.9
1,000 and over	100.0	62.0	22.1	15.9

The difference between small and large employers is greater when extreme sizes are compared. Forty-nine percent of employers with 1 to 3 workers but 82 percent of those with 5,000 or more workers emphasized basic education. On the other hand, 29 percent of employers with 1 to 3 workers emphasized specialization, while only 12 percent of the large employers did so.

Apparently, fewer small employers than large ones believe they can give specialized training and instead look to the schools to give it. This view is supported by chapter IX, below, which shows that, unlike large employers, relatively few small employers carry on organized training for persons in technical occupations. Also, data presented earlier (chapter IV) showed that in industries characterized by small employers recruiting was relied upon to a greater extent than upgrading and training as a source of workers in technical occupations.

To some extent the opinion of persons interviewed may be conditioned by how close they are to work areas. In some large establishments where several persons were interviewed, the field interviewers reported that personnel directors or chief engineers stressed basic education, while the department or project head indicated a preference for workers qualified to do the job. Some personnel directors who stressed the importance of basic education at the same time indicated that they would like to have highly specialized applicants who would be immediately productive.

VIII. TECHNICIAN-ENGINEER AND TECHNICIAN-SCIENTIST RATIOS

The ratio of technician to engineer and scientist employment has been used as a measure of the effectiveness with which employers utilize technical manpower. Chances are that an employer who splits off the less difficult functions of engineers and scientists and turns them over to qualified technicians makes more efficient use of technical manpower resources than a similarly situated employer who requires his engineers to perform the less complex as well as the more complex duties. Differences between employers' technician-engineer ratios measure differences in utilization and may indicate degrees of under-utilization of technical manpower.

VARIOUS RATIOS

More than a dozen ways of computing a ratio are described in this section, differing in what they include and exclude in the numerator and in the denominator. (Their results will be compared in table MM.)

RATIO #1

Ratio #1. *All persons in technical occupations.* Taking all technicians and technical specialists, as defined in the present survey, and comparing their number with the number of engineers and scientists employed (excluding high-school teachers) gives a ratio of 1.19 to 1; that is, there are 1.19 technicians and technical specialists for every engineer or scientist.—It will be stated simply as 1.19 (short for "1.19 to 1") and all other ratios similarly.

This "all persons" ratio varies substantially among the major industry groups and more widely among individual establishments.

The ratios in six of nine industry divisions (see the adjacent table KK) fall within the range of 0.75 to 1.25, but the ratios of the other three are much higher or lower: (1) The reason for the high ratio in the transportation, communication, and public utilities group is the relatively large number of equipment troubleshooters in air transportation and in communication, who work independently of engineers. (2) The explanation of the high ratio in private medical services is (a) there is a large number of laboratory assistants in hospitals and in medical and dental laboratories, and a large number of office assistants to dentists and physicians; and (b) practicing physicians and dentists are not included among the scientists who figure in the denominator of the ratio. (3) The low ratio of 0.26 in private colleges and schools is explained by the fact that the number of teachers far exceeds the number of hired semiprofessional laboratory and research assistants. Laboratory and research assistants who were primarily students were excluded from the survey.

Table KK. Ratio of Persons in Technical Occupations to Number of Engineers and Scientists, by Industry Division[a]

Industry division	Ratio
All industries	1.19
Manufacturing	1.08
Durable goods	1.18
Nondurable goods	0.75
Construction	0.96
Transportation, communication, and public utilities	2.98
Private medical services	8.98
Research labs and engineering services[b]	1.00
Private colleges and schools	0.26
Government	1.25
All other	1.14

[a] Engineers and scientists exclude high school teachers and medical and dental practitioners. They include college teachers and practicing engineers, scientists, mathematicians, and architects. (See chapter VI.)

[b] Includes architectural as well as engineering services; research, development, and testing laboratories; and business and management consulting services.

When one looks at the picture in individual establishments (see table LL), one is immediately struck by the fact that the majority of establishments (all counted in calculating over-all ratios) have engineers and scientists but no technicians or technical specialists, or vice versa. Page 16 of chapter II explains why so many establishments employ either engineers and scientists or technicians and technical specialists but not both.

Among the 6,237 establishments that employ both technicians and specialists and engineers and scientists the ratio varies widely; from the 400-odd in which the ratio is 0.25 or less to the 400-odd in which it is over 6.00. (See table LL, based on table 50 in supplement A to volume 1.)

Table LL. Distribution of Establishments According to Ratio of Persons in Technical Occupations to Engineers and Scientists

(See definition of ratio #1)

Ratio (number of persons in technical occupations per engineer or scientist)	Number[a]	Percent
Total	22,020	100.0
0.00[b]	7,524	34.2
0.01- .24	346	1.6
.25	116	0.5
.26- .49	429	1.9
.50	513	2.3
.51- .59	70	0.3
.60- .69	321	1.5
.70- .99	328	1.5
1.00	1,107	5.0
1.01- 1.49	334	1.5
1.50	226	1.0
1.51- 1.99	233	1.1
2.00	571	2.6
2.01- 2.99	311	1.4
3.00	464	2.1
3.01- 3.99	170	0.8
4.00	276	1.3
4.01- 4.99	79	0.4
5.00	154	0.7
5.01- 5.99	54	0.2
6.00	91	0.4
6.01- 9.99	223	1.0
10.00-19.99	160	0.7
20.00 and over	58	0.3
Technical occupations only	7,862	35.7

[a] Excludes high schools.

[b] Establishments that employ engineers or scientists, but no persons in technical occupations.

An over-all or gross ratio of this sort of course leaves much to be desired as a measure of the extent to which engineering and scientific functions are turned over to technicians. For one thing, the numerator of the ratio includes, along with the engineering and science technicians, a large number of technical specialists, such as safety and health inspectors and product testers and inspectors, whose jobs are largely unrelated to work performed by engineers and scientists. For another thing, the ratio lumps together technicians and engineers and scientists in different fields.

RATIOS #2—#7

A number of ratios were computed after excluding the technical specialists from the numerator, leaving only engineering and science technicians.

In defining these technicians, chapter II (table O) divided them into three groups: Primary Engineering Technicians, Secondary Engineering Technicians, and Science Technicians:

Primary Engineering Technicians

Structural design technicians (excluding loftsmen)
Electro and mechanical engineering technicians: design and development
Mathematics technicians
Quality control and reliability technicians
Surveyors
Civil engineering and construction technicians
Industrial engineering technicians, general

Secondary Engineering Technicians

Draftsmen
Loftsmen
Electro and mechanical engineering technicians: installation and troubleshooting
Time and motion study men and standards setters
Industrial process methods men
Broadcasting and studio equipment and maintenance technicians

Science Technicians

Physical science technicians
Biological and medical laboratory technicians, including agriculture and related
Therapists

This division points toward the following ratios:

Ratio #2. *Primary and secondary engineering technicians.* This ratio relates the number of primary and secondary engineering technicians to the number of engineers, architects, and mathematicians, excluding college teachers.

Ratio #3. *Science technicians.* This ratio relates the number of science technicians to the number of physical and life scientists, excluding college teachers.

Ratio #4. *Primary engineering technicians.* Inasmuch as the secondary technician group includes drafting, troubleshooting, and other jobs that are not considered engineering functions in many instances, a further refinement of the engineering technician ratio may be made by excluding them and limiting the ratio to the primary group.

Ratios #5, #6, and #7. *Technicians in relation to research, development, and production engineers and scientists.* Three more refined ratios, paralleling #2, #3, and #4, respectively, can be made by excluding from the denominator, in each case, all teachers and engineers and scientists engaged in administration and sales work. This exclusion is made because such persons typically do not utilize technician assistants. The remaining engineers and scientists, the persons left in the denominator, are primarily engaged in research, design, development, and production functions. (See chapter VI, above.)

RATIOS #8—#10

Ratios #8, #9, and #10 further limit both the numerator (technical-level employees) and the denominator (engineer-level employees):

Ratio #8a. *Electro and mechanical design and development technicians.* In this ratio the numerator is limited to electro and mechanical engineering technicians who are engaged in design and development work. The denominator includes the number of electrical, electronic, mechanical, and aeronautical engineers, but not those engaged in sales or administration.

Ratio #8b. *Ratio #8a plus draftsmen.* This ratio adds to the #8a numerator the number of nonconstruction electro and mechanical draftsmen.

Ratio #9. *Ratio #8a plus industrial engineering technicians.* This ratio adds to the numerator of ratio #8a the number of industrial engineering technicians and specialists, and to its denominator the number of industrial engineers.

Ratio #10a. *Ratio #9 plus physical science technicians.* This ratio adds to the numerator of ratio #9 the number of physical science technicians, and to its denominator the number of physical scientists. In this ratio mathematics technicians are included in the numerator and mathematicians in the denominator. Metallurgical engineers also are included in the denominator.

Ratio #10b. *Ratio #10a plus draftsmen and troubleshooters.* This ratio adds to the ratio #10a numerator the number of nonconstruction electro and mechanical draftsmen and troubleshooters.

RATIO #11

Ratio #11. *Civil and construction engineering technicians.* This ratio compares the number of civil engineering and construction technicians to the number of civil and construction engineers (omitting sales, teaching, and administrative engineers).

Ratio #11a includes the civil engineering and construction specialists, namely instrumentmen, construction inspectors, cost estimators, and specification writers.

Ratio #11b excludes these civil engineering and construction specialists.

Ratio #11c adds construction draftsmen and designers to the numerator of ratio #11a.

Table MM shows how the various ratios work out in each of the six major industry divisions, as well as on an aggregate basis. Ratios #2, #3, and #4 are raised noticeably though not substantially when engineers and scientists engaged in teaching, sales, and administrative work are excluded from the denominator (as in ratios #5, #6, and #7).

The more refined ratios, those which presumably better measure the utilization of technicians in performing functions of engineers and scientists, are ratios #8, #9, #10, and #11. These ratios to a greater extent than the others limit the comparisons to technicians and engineers (and/or scientists) engaged in similar kinds of work.

Table MM. Industry-Division Ratios of Technicians to Engineers and Scientists

(For each of fourteen types of ratio)

Ratios[a]	All industries	Manufacturing	Construction	Transportation, communication, and public utilities	Research labs and engineering services[b]	Government	All other
Ratio # 1	1.19	1.08	0.96	2.98	1.00	1.25	1.21
Ratio # 2	0.87	0.83	0.54	2.45	0.86	0.67	0.79
Ratio # 3	1.09	0.71	[c]	2.66	0.43	1.36	1.91
Ratio # 4	0.34	0.38	0.37	0.24	0.33	0.36	0.17
Ratio # 5	1.06	0.97	0.80	2.64	0.95	0.70	1.80
Ratio # 6	1.24	0.78	[c]	2.83	0.48	1.45	2.45
Ratio # 7	0.41	0.43	0.55	0.26	0.36	0.38	0.40
Ratio # 8a	0.58	0.69	[c]	0.11	0.72	0.15	1.15
Ratio # 8b	1.01	1.18	[c]	0.25	1.23	0.28	2.20
Ratio # 9	0.74	0.86	[c]	0.15	0.68	0.78	0.85
Ratio #10a	0.73	0.82	[c]	0.18	0.59	0.70	0.78
Ratio #10b	1.50	1.40	0.35	2.84	0.90	1.39	2.40
Ratio #11a	1.01	0.13	1.87	2.41	0.64	0.84	0.73
Ratio #11b	0.47	[c]	0.82	1.18	0.30	0.44	0.15
Ratio #11c	1.33	0.48	2.20	4.08	1.47	0.86	1.61

[a] See text for description of ratios.
[b] Research, development and testing laboratories; engineering and architectural services; and business and management consulting services.
[c] Few or no persons in the technician category.

MEASURES OF UTILIZATION

Whichever ratio is used, one cannot conclude that an establishment is using too few (or too many) technicians per engineer or scientist unless one has an idea of what a normal ratio is.

The present section discusses two norms or standards that can be computed from the survey data, which show existing practice:

If an array is made for any one ratio—for example, if all establishments are listed with reference to their #8a ratio, beginning with the one having the smallest ratio, the *median ratio* is the one in the middle of the array, and the *third-quartile ratio* is the one three-quarters of the way down the array. (Table NN gives a compressed view of eight such arrays, for ratios #8—#11.)

Use of the median ratio as a standard means that average experience is accepted as an attainable standard for all establishments whose ratios are lower. The third-quartile ratio sets a higher standard; it assumes that three-fourths of the establishments could attain a higher ratio of technicians to engineers or scientists.

Since, as already suggested, these ratios vary greatly by size of establishment, it is necessary to take this factor into consideration in calculating the degree of under-utilization of technicians.

A striking characteristic of the distribution under each ratio in table NN is the high proportion of establishments that show a zero (0.00) ratio because they have engineers or scientists but no technicians. These tend to be establishments that employ only a few engineers or scientists (table OO).

In the case of ratio #8a, for example, the relevant technician force of the 4,577 establishments involved in this ratio would rise by 15.8 percent if every establishment hired enough additional technicians to raise its ratio to the *median* of its size group as shown in table OO. Establishments with fewer than 10 relevant engineers or scientists would not change their ratios, since in those size groups the median is zero.

If the *third-quartile ratio* were used as the standard, instead, the number of relevant technicians employed would rise by 41.5 percent.

Table NN. Establishment Ratios of Technicians to Engineers and Scientists

(Percent distribution of establishment ratios, for each of eight types of ratio[a])

Establishment-ratio level	Ratio #8a	Ratio #8b	Ratio #9	Ratio #10a	Ratio #10b	Ratio #11a	Ratio #11b	Ratio #11c
All establishments: Number	4,577	4,975	5,441	7,126	7,714	3,810	2,972	5,356
Percent distribution								
All establishments: Percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
0.00[b]	65.5	45.3	62.6	61.2	46.7	42.4	61.9	31.8
0.01- .24	1.9	1.7	1.8	1.9	1.3	0.8	1.5	0.7
.25	0.5	0.2	0.4	0.3	0.2	0.6	0.6	0.5
.26- .49	3.6	3.8	3.3	2.8	2.7	1.2	1.8	1.6
.50	2.1	4.3	1.7	1.5	2.9	1.3	1.5	2.0
.51- .59	0.7	0.4	0.6	0.9	0.7	0.3	0.2	0.2
.60- .69	1.1	1.7	1.1	1.3	1.3	0.7	0.4	0.8
.70- .99	2.0	3.3	2.2	2.4	2.6	1.2	1.2	1.2
1.00	4.5	7.4	4.6	4.6	6.0	2.7	3.0	5.5
1.01- 1.49	1.6	2.3	1.8	1.9	2.4	1.4	0.5	1.8
1.50	0.3	0.6	0.8	0.7	1.0	0.2	0.2	1.2
1.51- 1.99	0.6	1.2	0.7	0.9	1.3	0.3	0.5	0.7
2.00	1.9	3.2	2.2	1.8	3.0	2.2	4.0	3.8
2.01- 2.99	0.5	1.4	0.8	0.9	1.8	1.0	2.0	1.3
3.00	0.5	1.5	0.7	1.2	1.8	3.0	2.4	3.1
3.01- 3.99	0.1	0.4	0.4	0.4	0.8	0.2	0.4	0.7
4.00	0.6	0.7	0.5	0.7	0.8	3.6	0.9	2.7
4.01- 4.99	0.1	0.2	0.1	0.1	0.2	0.4	[d]	0.4
5.00	0.1	0.4	0.3	0.1	0.4	0.8	0.4	1.0
5.01- 5.99	0.1	0.2	[d]	0.1	0.1	0.1	—	0.1
6.00	0.3	0.4	0.2	0.1	0.4	0.1	—	0.4
6.01- 9.99	0.2	0.6	0.4	0.4	0.7	0.5	0.5	1.0
10.00-19.99	[d]	0.3	0.2	0.2	0.6	0.4	[d]	0.6
20.00 and over	[d]	0.2	[d]	[d]	0.2	0.1	—	0.1
Technicians only[c]	11.2	28.3	12.6	13.6	20.1	34.5	16.1	36.8

[a] See text for description of ratios.
[b] Engineers and/or scientists only.
[c] No engineers or scientists.
[d] Less than 0.05 of a percent.

Table OO. Median and Third-Quartile Establishment Ratios of Technicians to Engineers and Scientists,[a] by Number of Engineers and/or Scientists in Establishment

Number of engineers and/or scientists in establishment[b]	Ratio #8a	Ratio #8b	Ratio #9	Ratio #10a	Ratio #10b	Ratio #11a	Ratio #11b	Ratio #11c
				Median ratios				
All relevant establishments[c]	0.00	0.44	0.00	0.00	0.42	1.00	0.00	2.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.34	0.00	0.00	0.33	0.00	0.00	0.35
4- 5	0.00	0.50	0.00	0.00	0.68	0.25	0.00	0.97
6- 9	0.00	0.50	0.09	0.14	0.54	0.42	0.00	0.93
10-19	0.38	0.81	0.44	0.53	0.90	0.01	0.00	0.80
20-49	0.30	0.60	0.49	0.53	0.60	0.00	0.00	0.47
50 or more	0.37	0.46	0.40	0.42	0.76	0.41	0.19	0.74
				Third-quartile ratios				
All relevant establishments[c]	0.61	2.00	1.00	1.00	3.00	[d]	2.00	[d]
1	0.00	0.00	0.00	0.00	0.00	1.00	0.00	2.00
2	0.00	1.00	0.00	0.50	1.00	0.50	0.00	1.50
3	0.29	0.67	0.33	0.36	0.67	1.17	0.41	2.00
4- 5	0.25	0.99	0.76	0.92	1.50	0.99	0.31	1.48
6- 9	0.66	1.21	0.65	0.74	1.59	1.14	0.85	1.84
10-19	0.88	1.35	1.00	1.00	1.57	0.66	0.34	1.84
20-49	0.79	1.03	0.95	0.87	1.26	0.55	0.16	1.25
50 or more	0.64	0.88	0.69	0.72	1.23	1.08	0.66	1.26

[a] See text for description of ratios.
[b] The number of engineers and scientists is limited to the type included in the denominator of the ratio.
[c] Over-all ratios include establishments employing persons in technical occupations but no engineers or scientists, as well as establishments with engineers or scientists. "Relevant establishments" means those with the types of technical occupation and the types of engineer or scientist included in the ratio in question.
[d] Infinite ratio, because no engineers or scientists are employed.

The corresponding percentage increase in the number of technicians employed is as follows for seven ratios in addition to #8a:

Ratio	*Median*	*Third quartile*
Ratio #8a	15.8	41.5
Ratio #8b	11.4	31.3
Ratio #9	13.3	36.7
Ratio #10a	11.5	35.7
Ratio #10b	7.9	27.9
Ratio #11a	7.1	40.0
Ratio #11b	4.0	39.4
Ratio #11c	9.6	40.9

These figures suggest that if average industry practice is taken as a standard, anywhere from 7 to 16 percent more technicians could be used (ratio #11b calls for only 4 percent); and that if above-average practice were used as a standard, the increases would be substantially greater.

How realistic these figures are, is hard to say. Probably none of the ratios is sufficiently precise to screen out technicians doing work unrelated to that of engineers included in the same ratio, and vice versa.[1]

The data do suggest that there is under-utilization of technicians in relation to engineers and scientists. Realistic standards might well be ratios somewhat below the medians.[2]

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[1] There is a danger, however, that further refinement would enhance characteristics of the survey data that tend to obscure true relationships. For example, a company with multiple establishments may concentrate its engineering staff in a central office establishment but employ prototype testers or troubleshooters in each of several field establishments. Or a firm with one or two engineers may contract out its drafting work to an outside service firm. In these examples the establishment ratios might come out as zero, which would be misleading so far as the true situation in the firm is concerned.

[2] What would happen to engineer or scientist employment if the technician ratio were increased is beyond the scope of the present inquiry. One might assume, however, that expansion would on the whole absorb any potential displacement.

IX. EMPLOYER TRAINING OF TECHNICAL PERSONNEL

One part of the technical occupation picture that the present survey has sought to illuminate is the role that employers have assumed in training technicians and technical specialists. Apart from providing work experience, do employers make a significant contribution to organized training in this field? What is the nature of their programs, and in what kinds of establishments is training most likely to be found?

Employer training for technical work may be designed to supplement the knowledge of mathematics, science, and engineering principles obtained in the schools (high schools, technical institutes, and colleges) by teaching the technologies involved in applying these principles, or more narrowly in teaching technical skills and practical applications required in the particular plant.

On the other hand, employer training may be designed to give to workers who have a practical background and technical skills a grounding in theory and principles—in order to develop their capacity to perform higher-level work. To this end the employer may organize special courses to be given in the schools for his employees, or may encourage his employees to take courses offered by the schools. Or, if the schools do not offer instruction in the field of interest, the employer, especially if he runs a large business, may set up a course of instruction in his own plant.

The two broad objectives of employer training—understanding of technology and knowledge of basic principles—may in practice be combined in one program, but often the first is handled in some kind of on-job training while the second is carried out through tuition-refund arrangements.

A "Tuition-Refund Program" is an arrangement in which the employer pays or refunds the tuition for courses taken by employees in high schools, technical institutes, and colleges. The initiative in signing up for courses typically is left to the employee. The courses must hold promise of helping the worker improve his performance in the job he holds, of improving his eligibility for promotion, or generally of helping to improve the qualifications of the worker in the technical field.

An "On-job Training Program" is one in which there is a prearranged training program organized or utilized by the employer in which a course of instruction and/or job training is carried out in the employer's establishment.

EXTENT OF EMPLOYER TRAINING

The data indicate that relatively few employers engage in organized training in technical occupations, which suggests that the formal training function in this field is performed primarily by high schools, technical institutes, and colleges.

On-job experience as such, of course, also has a highly significant role in the learning process; it is not included here as a form of organized training.[1]

The survey schedule asked two questions:

"Do you have tuition refund, scholarship, or related types of plans for employees?"

"Do you have at the present time an on-the-job training program in your establishment which is designed to qualify employees (in whole or in part) for jobs in technical occupations?"

Slightly over 1,350 or 9 percent of all establishments in New York State with technical occupations had tuition-refund programs in 1962. A smaller number (6 percent) had on-job training programs. Combining these groups, 12 percent of the establishments had either one or both (table PP). The proportion of all technical occupation personnel in these programs is probably greater than 12 percent, since the programs are typically in larger establishments.

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[1] Excluded from this discussion also is training designed solely to improve skills used in existing job assignments.

Table PP. Percent of Establishments with Technical Occupations Having On-Job Training or Tuition-Refund Program, by Industry Division

Industry division	On-job training	Tuition-refund	One or both
All industries	6.0	9.3	12.4
Manufacturing	10.7	24.0	28.0
Construction	2.6	3.2	4.3
Transportation, communication, and public utilities	13.8	19.8	25.1
Private medical services	3.0	0.8	3.5
Research labs and engineering services[a]	3.2	4.3	6.9
Private colleges and schools	9.0	29.2	32.6
Government	9.1	3.8	10.5
All other	8.3	15.9	17.9

[a] Includes architectural as well as engineering service enterprises; research, development, and testing laboratories; and business and management consulting services.

The highest proportion of establishments having programs is found in the manufacturing field, in the field of transportation, communication, and public utilities, and in private colleges and schools. (Further detail in table 51, in supplement A to volume 1.)

It seems clear that persons given training under programs organized by employers are a small minority of all persons training in the schools and on the job. Chapter IV reported that of all persons upgraded by employers in technical occupations, only about 6 percent were given training by the employer in the process. This does not reflect the full scope of employer training but it supports the conclusion that employer-organized training is of comparatively small dimensions in the technical occupation field. It seems probable that not over 10 percent of persons going into entry-level or higher grades of technical jobs in 1962 participated in training programs organized by employers to help qualify them for these jobs.[1]

The proportion having tuition-refund or on-job training programs is far higher among large establishments with technical personnel than among small ones. Around 85 percent of all manufacturing establishments with 5,000 or more employees, for example, have tuition-refund plans, and two-thirds have on-job training programs. In contrast, relatively few manufacturing plants with under 50 workers have such programs. (See table QQ, based on table 52 in supplement A to volume 1.)

The Buffalo, Rochester, and Utica areas have the highest proportion of establishments with such tuition-refund and on-job training programs. (Table 51.)

The low rate of training in small establishments is a situation that has been found in other occupations as well as in technical employment.[2] Probably in large part it is explained by the greater per capita costs of training in small establishments, as well as by a lack of personnel specialized in the training function.

In some instances—especially in medium-size establishments—the absence of training was explained by ups and downs of defense-contract business, which made it impractical to embark on systematic training efforts.

Table QQ. Establishments with On-Job Training or Tuition-Refund Program as Percent of All Establishments with Technical Occupations, in Two Size Groups, by Industry Division

Industry division	On-job training		Tuition-refund	
	Under 50 employees	5,000 or more employees	Under 50 employees	5,000 or more employees
All industries	2.5	46.4	2.6	52.2
Manufacturing	3.9	66.7	8.7	85.7
Construction	3.3	—	2.7	—
Transportation, communication, and public utilities	2.2	87.5	1.6	75.0
Private medical services	1.2	—	0.2	—
Research labs and engineering services[a]	2.4	—	2.3	—
Private colleges and schools	15.4	33.3	7.7	100.0
Government	12.1	18.5	2.6	14.8
All other	2.6	50.0	6.3	50.0

[a] Includes architectural as well as engineering service enterprises; research, development, and testing laboratories; and business and management consulting services.

CHARACTERISTICS OF PROGRAMS

Information was obtained on 196 tuition-refund programs and about the same number of on-job training programs. These are believed to be representative of such programs in New York State in respect to their general characteristics.

Tuition-refund programs

The typical tuition-refund program does not specify eligible courses or define the area of subject matter specifically. While courses must be approved, the employer's decisions will be based on the job situation and prospects of the individual worker.

However, courses are restricted to certain subjects in 42 of 185 programs for which information on this point was available. These subjects were mostly specific kinds of technology or branches of engineering, such as drafting, electronics, estimating, mechanics, and chemistry.

Most tuition-refund plans do not limit eligibility to certain types of worker: no limitation was found in 124 of 182 plans for which this kind of information was available.

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[1] This estimate does not include breaking-in training given to acquaint already qualified workers with the demands of the particular job. This usually is done through instruction by the worker's supervisor or by other experienced workers.

[2] See, for example, New York State Department of Labor, *Manpower in Selected Metal Crafts, New York State*, Publication B-107 (1959), pages 18-42.

Among the 58 plans that did contain a limitation, in 36 cases it was based on length of service; the most common requirement was one year of service, the next most common six months.

In 22 cases the plan was restricted to certain occupations. These included draftsman, tool designer, electronic technician, laboratory technician, sales representative, tester, and also several more general categories.

Although a large proportion of tuition-refund plans provided for reimbursing 100 percent of the tuition costs, many provided for 50 percent:

Refund	*Plans*
100%	84
80	1
75	14
66⅔	5
65	2
62½	1
50	47
40	1
33⅓	1
Depends on grades	17
Dollar amounts	13
Not reported	10

A passing grade is almost always a condition for reimbursement; and a grade of "C" is often required.

About half the plans provided for paying part or all the registration and laboratory fees; considerably less than half covered the cost of text books.

On-job training programs

This section summarizes the general characteristics of 145 on-job training programs—excluding programs involving the training of data-processing personnel and medical technicians, which are referred to at a later point in the chapter.

Participation in on-job training plans, as in tuition-refund plans, is essentially voluntary. However, in 17 of the 145 cases, participation was clearly mandatory, and there doubtless were a number of additional cases where employers strongly urged participation.

In 56 of the 145 establishments that had on-job training programs there was also a tuition-refund plan, one that applied to workers outside the on-job training plan as well as to those in it.

On-job training programs in the technical occupation field may be designed to (A) train craftsmen to become qualified workers in a technical occupation; (B) train workers in some technical occupations to become qualified workers in other technical occupations; or (C) train beginning workers or workers without craft or technical occupation experience to become qualified workers in technical occupations.

Nearly half the plans were a combination of C and A and/or B:

Type of workers to be trained	*Number*
A. Craftsmen	12
B. Workers in technical occupations (to be trained in others)	13
C. Beginning workers or workers without craft or technical occupation experience	40
Type C in combination with A and/or B	65
Combination of A and B	6
Type not reported	9

The frequency with which type C appears alone or in combination indicates that a large majority of the programs were open to all qualified workers rather than only those with craft or technical experience.

Skills or subject-matter knowledge to be developed by these programs had a wide range. They were reported in roughly the following order of frequency: Drafting; electronics, electricity, electro-mechanical instrumentation; testing, inspection, quality control; generally, skills needed for next higher grade of position; time study, work standards setting; knowledge of company's operations and products; operation of technical equipment, use of tools, production skills, etc.; supervisory skills; designing; troubleshooting; mathematics, physical science subjects; mechanics; surveying; blueprint reading; use of schematics; technical writing and editing; estimating, planning; data processing.

Various kinds of on-job instruction are utilized in these programs. The most common was personalized "shoulder-to-shoulder" on-job training by senior personnel or supervisors:

A. Personalized instruction on the job	89
B. In-plant films, demonstrations, lectures, courses, seminars	19
C. Combinations of A and B	27
D. Manufacturer's school training (maintenance of new equipment)	2
Not reported	6

In 39 of the programs, classroom instruction in schools and colleges was part of the training program. In the vast majority of these the course work was carried on in a technical institute, community college, or university. Tuition for these courses was usually paid by the employer, but there were several cases in which the employee was required to pay such costs.

TRAINING OF MEDICAL TECHNICIANS AND SPECIALISTS

Hospitals and medical laboratories engaged in on-job training of their own employees for medical technician and specialist occupations typically conduct informal programs. Generally, these programs are aimed at teaching inexperienced high-school graduates to perform medical laboratory tests or to operate such diagnostic equipment as electrocardiographs and electroencephalographs; but there are also programs that train workers in medical laboratory specialties or in more advanced testing techniques. The on-job training consists mainly of shoulder-to-shoulder instruction by experienced or supervisory technicians. Some programs, especially those for operating room technicians, include lectures and demonstrations in addition.

Formal training of medical technicians and specialists is largely confined to hospital schools, private trade schools, and community colleges. The following summary account of educational facilities available for medical technicians and specialists is not intended to be an exhaustive inventory.

In 1964, there were in New York State 40 schools of medical technology and 30 schools of X-ray technology approved by the Council on Medical Education and Hospitals of the American Medical Association. In addition, there were approved schools for cytotechnologists, clinical laboratory assistants, medical record librarians, and occupational and physical therapists.

The 30 X-ray schools offer a two-year course for high-school graduates. The 40 schools of medical technology offer one-year training in clinical laboratory technology to students who have completed three years of college, including specified courses in chemistry, biological sciences, and mathematics. Completion of the course at an approved school permits students to take the national examination for certification as medical technologists. (See chapter VI in volume 2 for a discussion of the requirements for certification of medical technologists and X-ray technicians.)

All 70 schools of medical and X-ray technology are operated by hospitals or medical laboratories,[1] which consider that they are building up a skilled labor force on which they as well as other hospitals and laboratories can draw. All but four of the medical technology schools and about half the X-ray schools are tuition-free.

Programs in X-ray and other medical technologies are offered by five private trade schools licensed by the New York State Education Department. In addition, a school of X-ray technology operated by a non-profit organization offers a two-year course, approved by the Education Department; about 25 hospitals in upstate New York participate by giving training to students of this school.

At least 12 of the community colleges and technical institutes affiliated with the University of the State of New York offer two-year programs for the training of medical laboratory technicians, dental hygienists, dental laboratory technicians, and also medical office assistants. A few of these schools offer practical laboratory experience to their students through agreements with local hospitals or laboratories.

TRAINING IN DATA-PROCESSING PROGRAMMING

One of the prominent fields of employer training in technical occupations is data-processing programming. Most formal training in this field is carried on in schools conducted by the manufacturers of the equipment, although some high schools, technical institutes, and colleges now offer courses. Very little formal training is conducted by the employers of programmers, except for the training given to other members of the staff by persons who have attended the manufacturers' schools.

Most courses given by manufacturers for users of their equipment range from two to eight weeks; in exceptional cases they run longer. The length of the course depends on the complexity of the computer and the kinds of peripheral equipment. A programming course on the IBM 1401 computer, for example, will involve less time than a course on the 7070 or 7090; coursework or experience in 1401 programming is usually required for those admitted to courses dealing with the 7000-series computers.

The courses given by the manufacturer are designed to qualify the trainee to start performing the functions of the programmer on the specific equipment. The assistance of the local manufacturer's customer engineer is available to the programmer and frequently is utilized.

The manufacturer requires that trainees for programming courses demonstrate their aptitude for this kind of work by passing the Programmers Aptitude Test. The employer of the trainee may have additional requirements, such as experience within the firm or industry in the functions to be programmed. For scientific programmers, a background in science and/or engineering is almost always a prerequisite. In some firms, the engineers and scientists are trained to do their own programming.

COOPERATIVE WORK-STUDY PROGRAMS

Cooperative work-study programs have a role of some importance in the technical occupations field. A work-study program requires rotating periods of classroom attendance and industrial employment in some phase of the trainee's field of study. Curriculum demands generally determine the length of the program and the method of alternating work with study. (Programs that involve only summer employment are not classified in this category.) Though graduates of the programs are not obligated to accept employment with cooperating firms, the participating companies consider the programs to be a source of competent specialized personnel. Student-trainees are employees of the cooperating firm during the work periods and often accrue seniority.

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[1] 68 of the 70 are hospitals.

The cooperative plan had its origins in the engineering schools, and probably a majority of the programs lead to a bachelor's degree. Programs have also been established in technical institutes and community colleges and in some high schools.

In 1963, at least twelve colleges and institutes in New York State, including seven technical institutes and community colleges of the State University of New York, offered cooperative work-study programs in engineering, science, building construction, and medical and dental technology. Over 1,000 New York and out-of-state firms cooperated in the programs, and approximately 7,200 students were enrolled in the courses.[1]

UNION TRAINING PROGRAMS

The expectation that automation and related technological innovations will result in the obsolescence of some craft skills and a demand for new technical skills has led some labor organizations unilaterally to provide educational and retraining programs designed to upgrade the skills of their members.

A good example is a program organized in 1964 by District 15 of the International Association of Machinists (IAM—AFL-CIO) with the cooperation of the U.S. Bureau of Apprenticeship and Training, which is designed to prepare journeymen tool-and-die makers and all-round machinists for the advent of numerically-controlled machine tools. The program, open to members who have been journeymen for five years or more, is conducted at three New York City evening trade schools. It consists of 20 bi-weekly, two-hour sessions in programming for and operating numerically-controlled machine tools. Over 400 members have applied for the course, which has a capacity of 75 at the three schools.

A broader program of courses has been conducted since 1952 by Local 418 of the International Union of Electrical, Radio, and Machine Workers (IUE—AFL-CIO) for its members at the American Bosch Arma plant in Nassau County. In 1962, the program was broadened to include the members of two sister locals, Local 460 (production and maintenance workers) and Local 464 (salaried workers). Twenty-hour courses were offered in such subjects as analog computers, the design of digital computers, basic electricity and mathematics, probability theory, electrical circuits, stable elements and gyrocompasses, and transistor circuitry. The courses, for which there was a $5 fee, were conducted at Westbury High School by graduate engineer members of Local 418, who are a substantial proportion of the local's membership. Plans were formulated to include more complex subjects, to relate the courses directly to on-the-job promotion and occupational advancement, and to offer similar courses to members of other IUE locals in the Long Island area. This program was substantially curtailed in 1964 because of defense production cutbacks.

Programs conducted by two New York City IUE locals to train troubleshooters for electronic computers (Local 459) and electronic communication and aerospace equipment (Local 431) have been terminated. The computer technician program was discontinued in 1963 because of insufficient demand in Local 459's jurisdiction. The Local 431 program was terminated as a result of a cutback in defense production.

Because of the increasing use of electronics in communication systems and in heating and air conditioning systems, and the new use of closed-circuit television guard and patrol systems in new buildings, Local 3 of the International Brotherhood of Electrical Workers (IBEW—AFL-CIO) has since 1957 been conducting courses in basic and industrial electronics for journeymen electricians in the New York City area. The courses, which have been approved by the New York City Board of Education, are held at an electronics laboratory located at the union's headquarters. The basic electronics course is scheduled for 13 weeks and the industrial electronics course for one and two years. These courses, which are tuition-free accommodate 240 students at one time.

The local also provides courses in blueprint reading, motor controls and generators, and switchboard and panel board wiring.

REGISTERED APPRENTICESHIP TRAINING

Training carried on under New York State's registered apprenticeship training program is primarily for craft occupations, in which training in manual and artisan skills is highly important. There are few registered programs in technical occupations, as these have been defined in the present survey.

Table RR shows that as of December 31, 1962 and December 31, 1963, apprentices were being trained in 60-odd technical occupation programs in the State.

Table RR. Apprentice Training in Technical Occupations

Technical occupations	End of 1963		End of 1962	
	Programs	Apprentices	Programs	Apprentices
All relevant occupations	66	194	63	183
Dental laboratory technicians	33	87	32	73
Draftsmen, total	24	74	22	77
Mechanical	14	61	18	71
Architectural	9	12	3	5
Electrical	1	1	1	1
Electronic laboratory technicians	8	32	7	31
Chemical laboratory technicians	1	1	2	2

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[1] "Students Go to Work," bulletin 18 of *How to Get Money for College*, New York, Bell-McClure Syndicate (1964).

The standard apprenticeship programs for these occupations require four years of on-job training supplemented by 144 hours per year of related instruction. Apprentices in all of the occupations listed above are required to take courses in safety, industrial and labor relations, and sketching and/or drawing. In addition, courses in blueprint reading are required for all but the dental technician apprentices. School courses in science and theory include:

> *For dental laboratory technicians:* inorganic chemistry, biology, physiology, dental histology and anatomy, bacteriology, physics, diseases of the mouth and teeth, and the use and application of X-rays.
>
> *For all draftsmen:* mathematics (including geometrical construction and estimating and specifications), physical properties of materials, and strength of materials.
>
> > *Mechanical draftsmen:* mechanics, machine design, metallurgy, heat treatment of metals, principles of tools, machines and equipment, and mechanical and machine processes.
> >
> > *Architectural and electrical draftsmen:* history of architecture, principles of engineering, theory and technology of jobs and processes, and the principles of drafting.
>
> *Electronic laboratory technicians:* electrical trade mathematics, basic and advanced electronics theory, electro-electronic design, and applied physics.
>
> *Chemical laboratory technicians:* mathematics (including algebra, logarithms, and application of formulas), application of chemical theories, equilibrium of chemical solutions, sampling processes, conservation of energy, atomic theory, descriptive chemistry and commercial processes, and applications of laboratory techniques.

TECHNICAL OCCUPATION TRAINING UNDER MDTA

A few training programs for technical occupations have been given in New York State under the Federal Manpower Development and Training Act of 1962 (MDTA).

Training under this act is designed to provide unemployed and underemployed persons with skills for which there is a demand. The act provides funds for training programs and for financial allowances to eligible trainees. Training allowances are paid up to a maximum of 52 weeks for occupational training.

In carrying out the program, the Division of Employment of the New York State Department of Labor has the responsibility for determining training needs and selecting, referring, and placing trainees, and the payment of training allowances. The New York State Department of Education has the responsibility to provide or arrange for training for persons referred to it by the Department of Labor.

Table SS gives data for courses completed, courses in progress, and courses approved but not yet started.

The comparative infrequency with which technical training appears among the MDTA programs can be explained in part by the exceptionally long training time that is required in most of these occupations. In part it results from the lack of demand for enough persons in a particular occupation in an area to justify setting up group training. The absence of individuals qualified to undertake training of this sort also may be a factor in some instances. It is possible under plans

Table SS. MDTA Training Programs in Technical Occupations

(Institutional and on-job training; as of December 31, 1964)

Technical occupation	Area	Training duration (weeks)	Number of persons who		
			Completed training	Were in training	Were in programs approved but not started
All relevant occupations	—	—	330	137	15
Draftsman, trainee	Binghamton	25	65	—	—
	Syracuse	25	12	—	—
	Binghamton	24	—	21	—
Draftsman (entry)	Watertown	28	13	—	—
Draftsman (youth)	Rochester	50	—	15	—
Electronic mechanic, computer (entry)	New York City	26	48	26	—
Electronic mechanic, computer (on-job training)	New York City	27	—	25	—
Electronic mechanic (entry)	New York City	37	79	—	—
Electronic mechanic (youth)	Rochester	51	—	—	15
Electronic mechanic (youth)	New York City	35	—	50	—
Electronic mechanic (entry)	Hicksville	40	21	—	—
Electronic mechanic (entry)	Yonkers	36	10	—	—
Tester, electrical	Olean	26	13	—	—
Tester, systems	New York City	30	69	—	—

Note: The Electronic Mechanic program is designed to prepare the trainees to repair electronic equipment such as computers, industrial controls, radar and missile control systems, and transmitters.

being developed in the MDTA program that single individuals will be referred for training in technical courses being given in public or private schools and technical institutes.

FUNCTIONAL TRAINING OF TROUBLESHOOTERS

Field consultants employed in the present survey were asked to keep an eye out for instances of functional training of troubleshooting technicians in industry. This method has potential significance because it dispenses with much of the formal course work involved in training technicians in the schools.

Functional training is a term that has been given to a procedure in which the learning process is organized around conditions that simulate those that the troubleshooters and repairmen will encounter on the job. It starts with a specific system or piece of equipment; it stresses learning by experiencing; it takes up the fundamentals of the technology only when needed for understanding. It starts by teaching recognition of what is normal and then gives the learner the opportunity to work on the actual equipment, to experience normality, to identify non-normality, and to take the corrective steps to get the equipment back to normal.

This kind of learning approach has been used with success in training Air Force electronic technician troubleshooters; not only has it reduced training time but also, according to reports, it has improved quality in some instances.[1] Strong preference for the method has been expressed by some representatives of private industry.[2] However, no evidence of its widespread systematic utilization in formal training programs was turned up in the present survey, though it undoubtedly is an element in many programs that also stress background theory.

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[1] See Henry J. Duel, "A Report on Air Force Experiments with Functional Training for Electronic Technicians," *Journal of the American Society of Training Directors*, November 1958, pages 20-25.

[2] John E. Warren (instrument engineer of Monsanto Chemical Company), "Industry Needs Troubleshooting Technicians," *Technical Education News*, January 1962, pages 11-12.

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